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1 Operating Mode Graphs

1.1 IPPV (Intermittent Positive Pressure Ventilation)

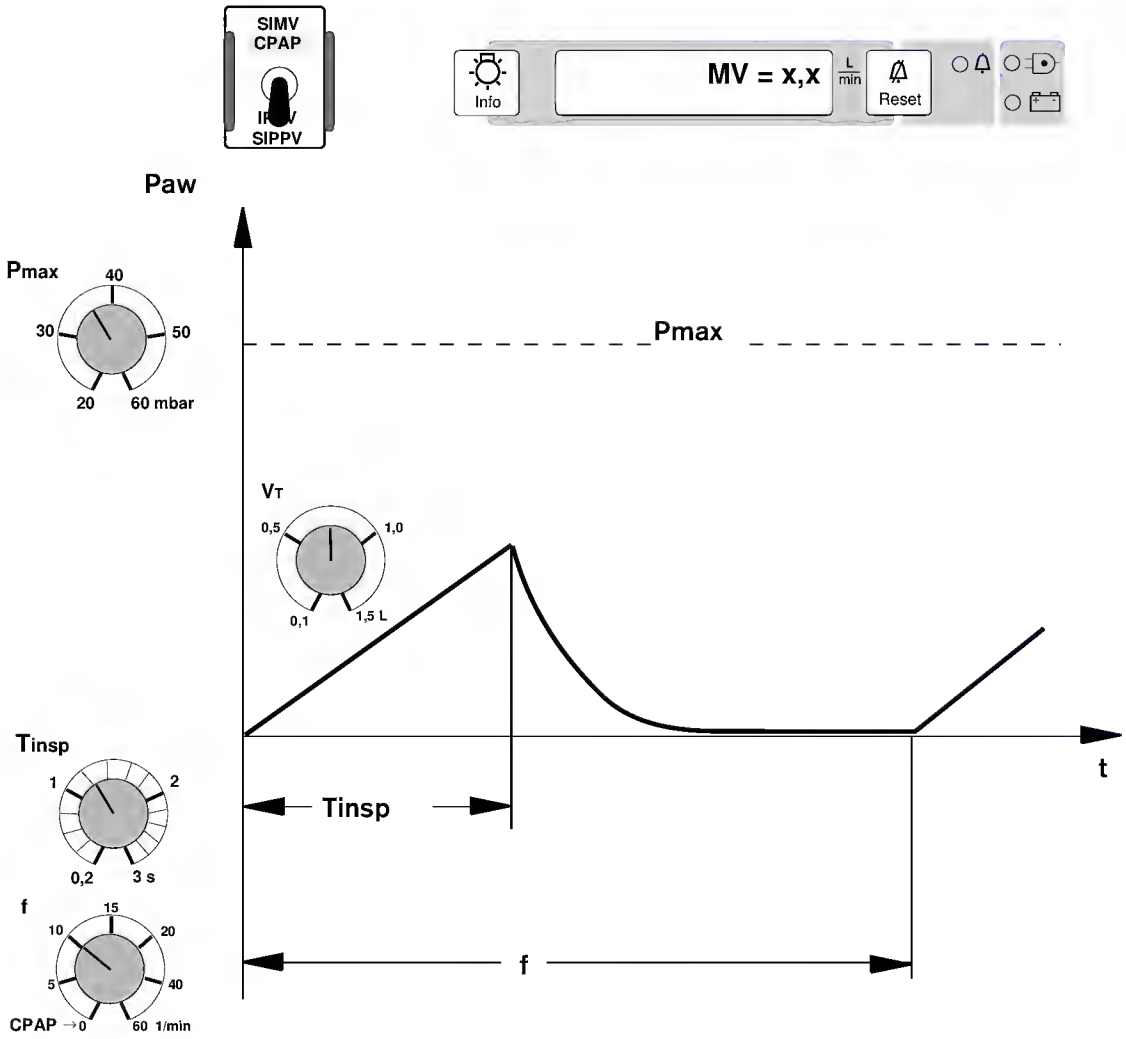

Fig. 1: IPPV

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1.1.1 IPPV Alarms

Paw high alarm

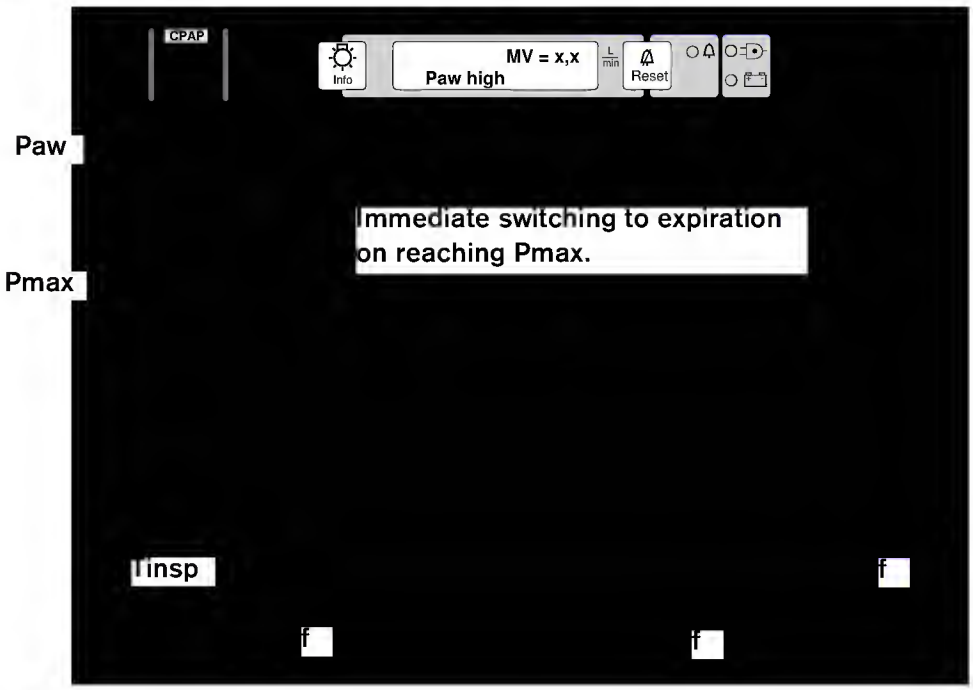

Fig. 2: IPPV, Paw high alarm

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Paw low alarm

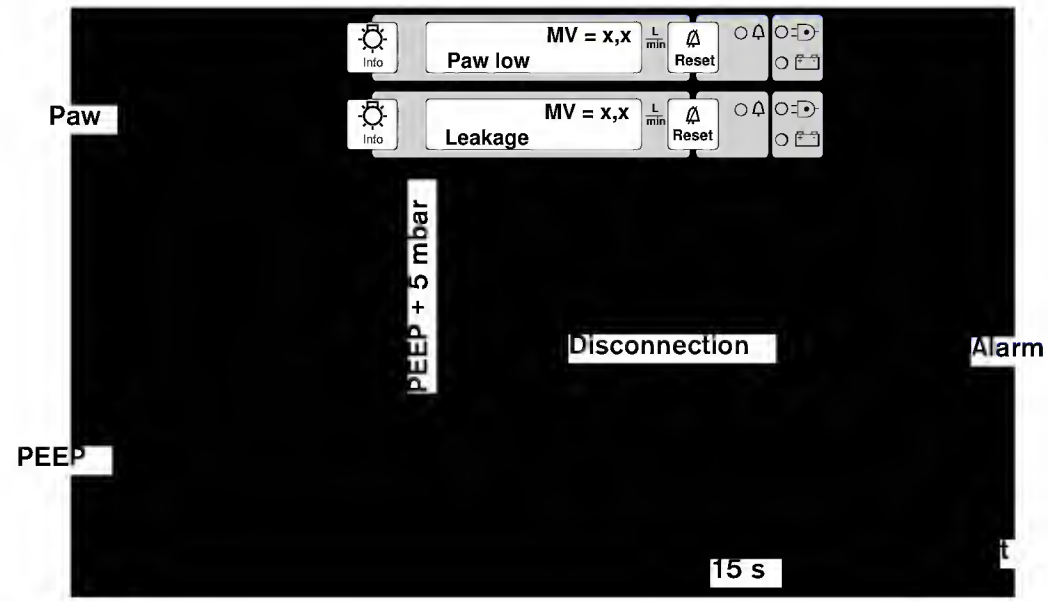

Fig. 3: IPPV, Paw low alarm

The disconnection alarm indicates that there must be a considerable leak, e.g. in case the tubing system has been disconnected.

An alarm is generated if the PEEP value + 5 mbar is not exceeded in the course of two consecutive breahts.

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1.1.2 Leakage

Leakage alarm

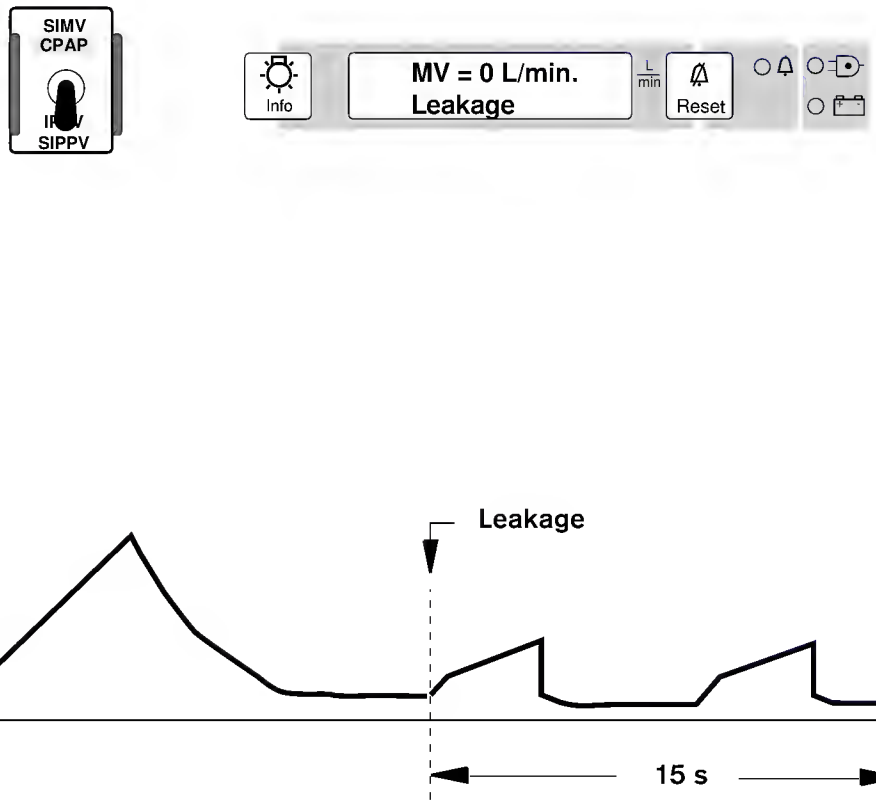

Fig. 4: IPPV, Leakage alarm

The leakage alarm indicates a loss of volume caused by e.g. fistulae, an unblocked cuff or leaks in the tubing system.

An alarm is triggered if the measured expiratory minute volume is less than 60% of inspiratory minute volume.

Visible and audible alarms after 15 seconds if leakage persists.

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1.1.3 IPPV-PEEP high

PEEP high alarm

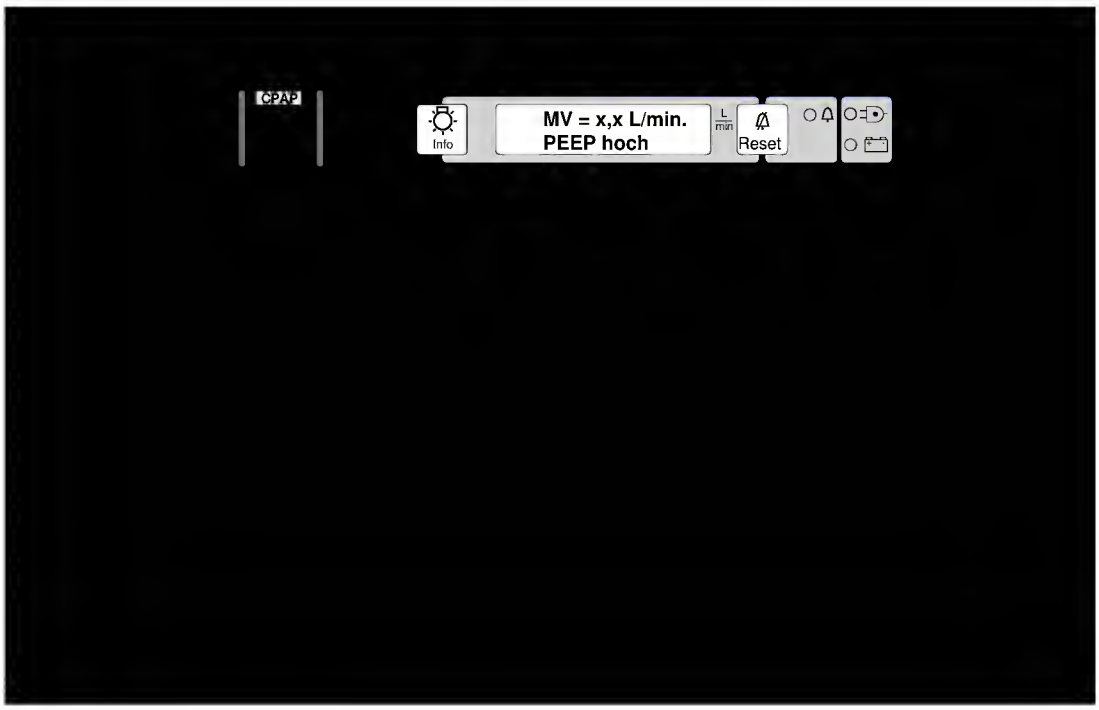

Fig. 5: IPPV, PEEP high alarm

The PEEP high alarm is triggered if the airway pressure P_{AW} does not drop below 22 mbar during the expiration phase.

Visual and acoustic alarms are given after 15 s.

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1.1.4 **IPPV with PEEP** (IPPV with positive end expiratory pressure)

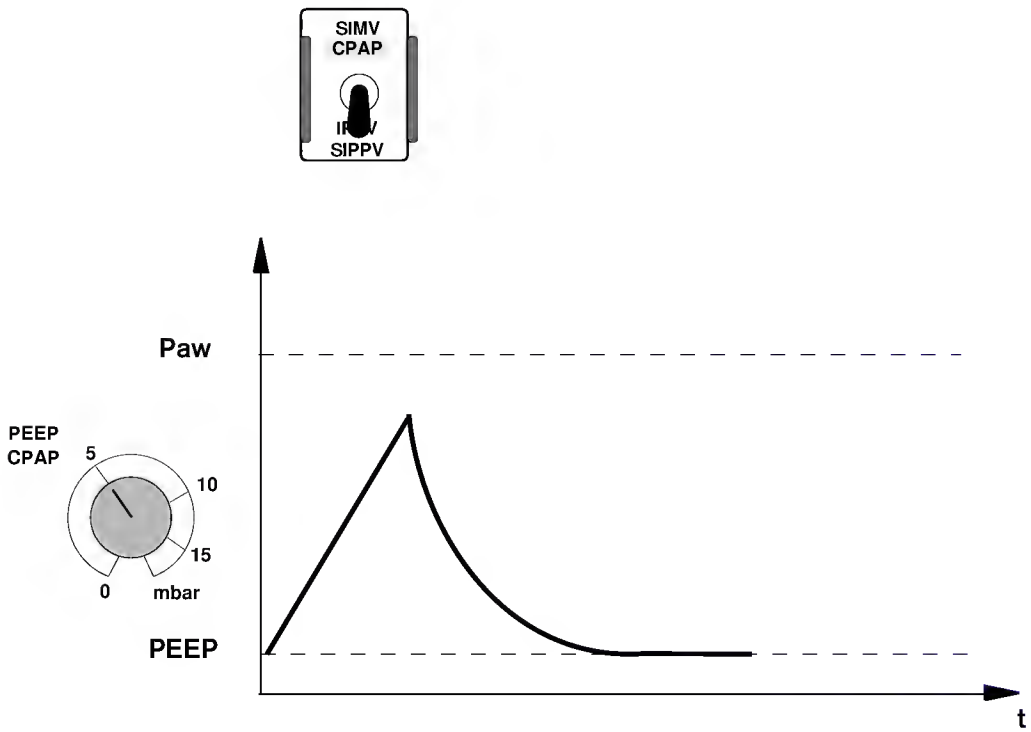

Fig. 6: IPPV with PEEP

Alarms as under IPPV.

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1.2 SIPPV (Synchronised IPPV)

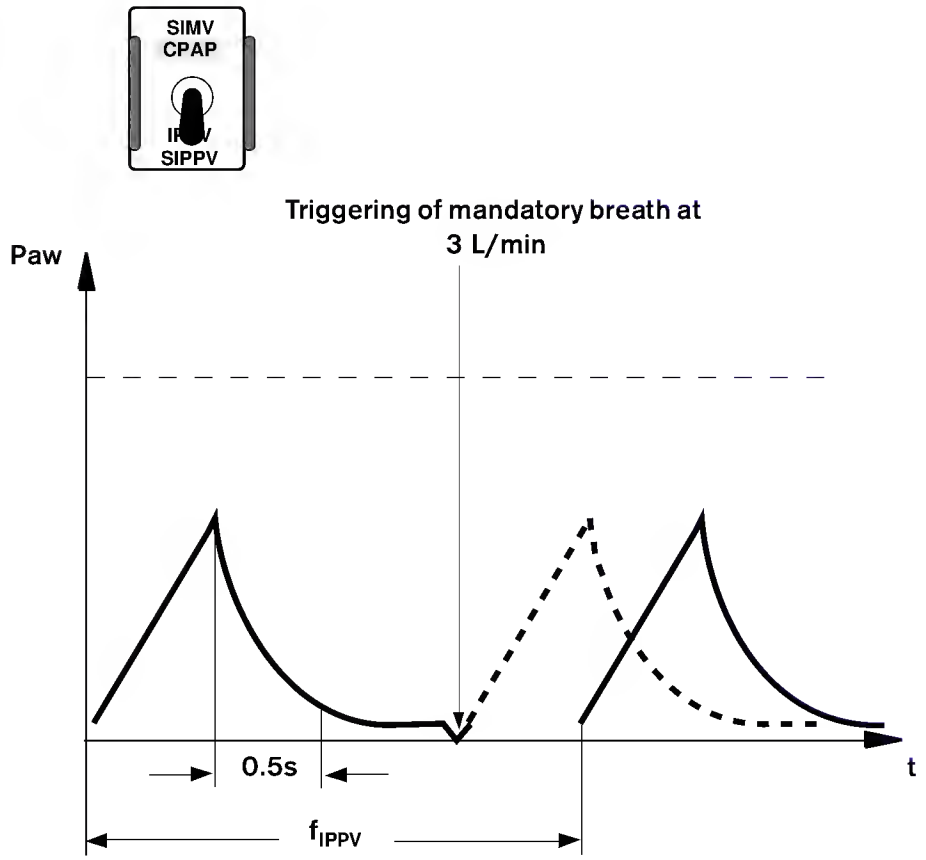

Fig. 7: SIPPV

If the patient triggers a breath within the trigger window, the frequency per minute will be increased.

To enter the SIPPV mode, set the mode selector switch to SIPPV. Then use the Info button to select SIPPV on the display and the Reset button to activate SIPPV.

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1.3 SIMV (Synchronised Intermittent Mandatory Ventilation)

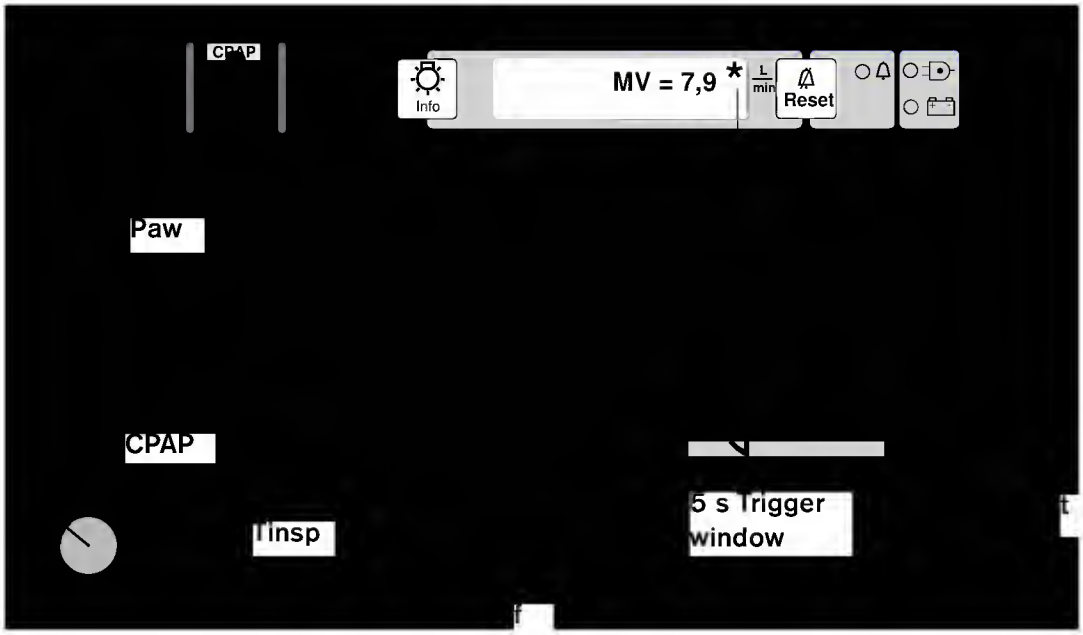

Fig. 8: SIMV

Reduction of frequency according to the patients demand: f.

Spontaneous breathing during the mandatory breaths on CPAP/ASB level.

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1.3.1 SIMV (Trigger Window)

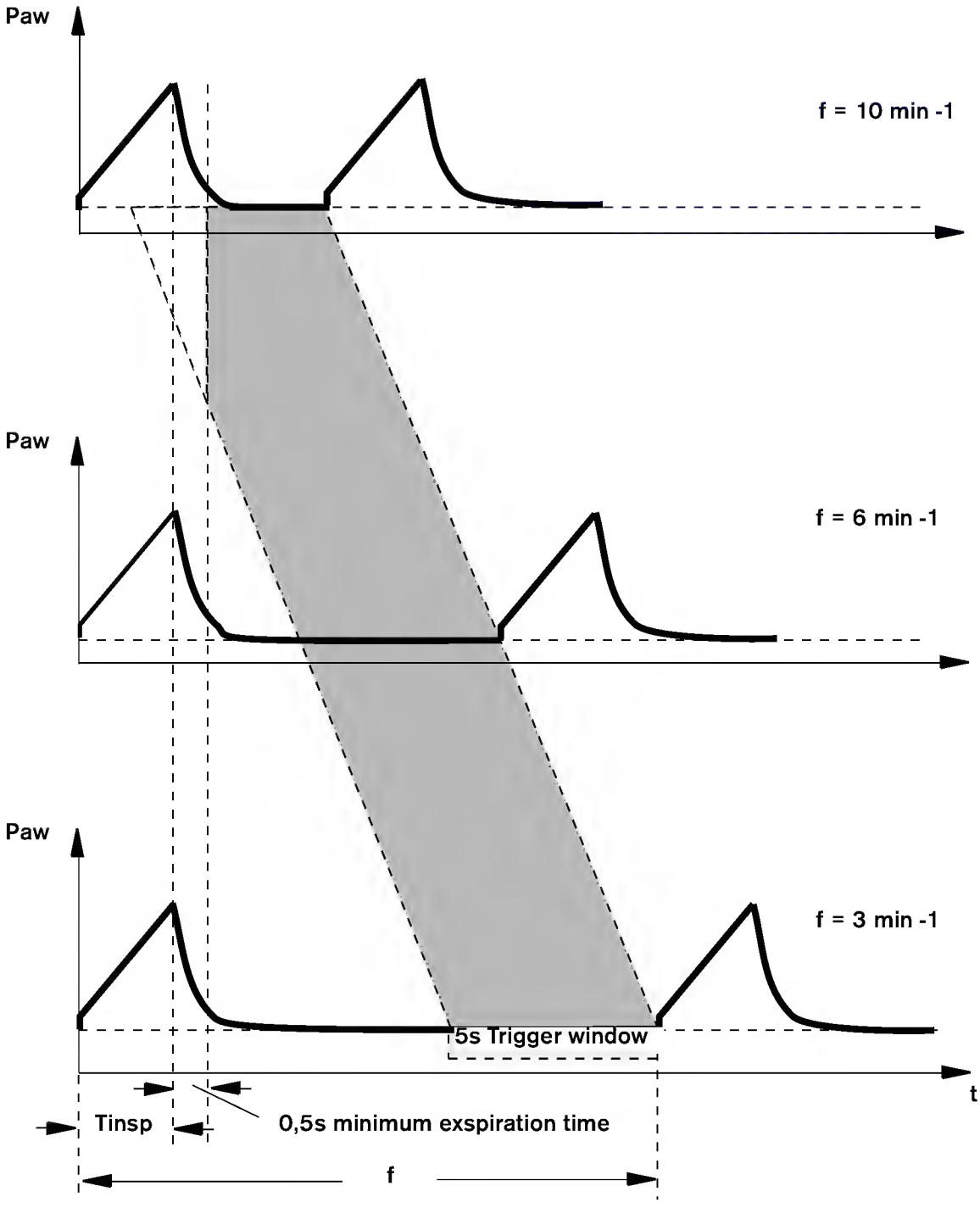

Fig. 9: SIMV, Trigger window

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1.3.2 SIMV (Fixed Frequency)

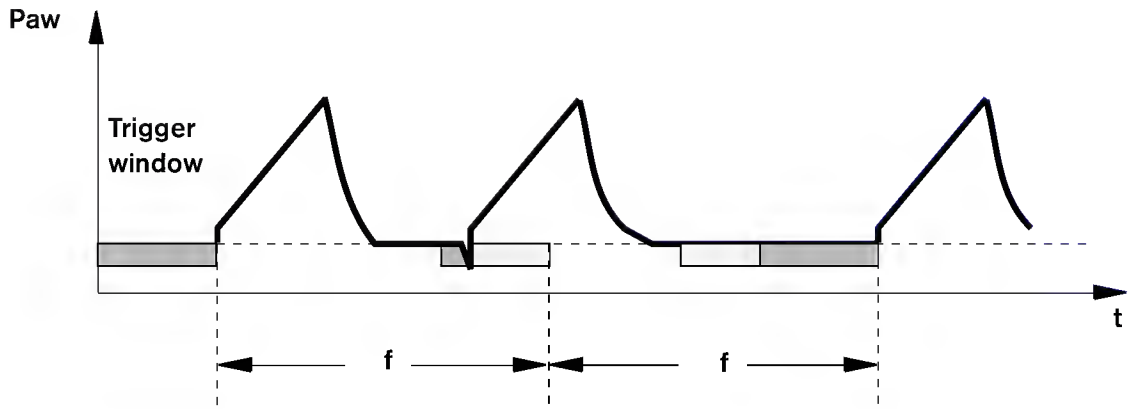

Fig. 10: SIMV (Fixed Frequency)

The trigger window lasts 5 seconds as long as the SIMV frequency is consistent.

If SIMV frequencies are higher, the trigger window will be equal to the total remaining spontaneous breathing time.

The distance between the trigger windows is identical with the SIMV cycle time and therefore constant.

Increase of frequency is not possible.

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1.4 CPAP (Continuous Positive Airway Pressure)

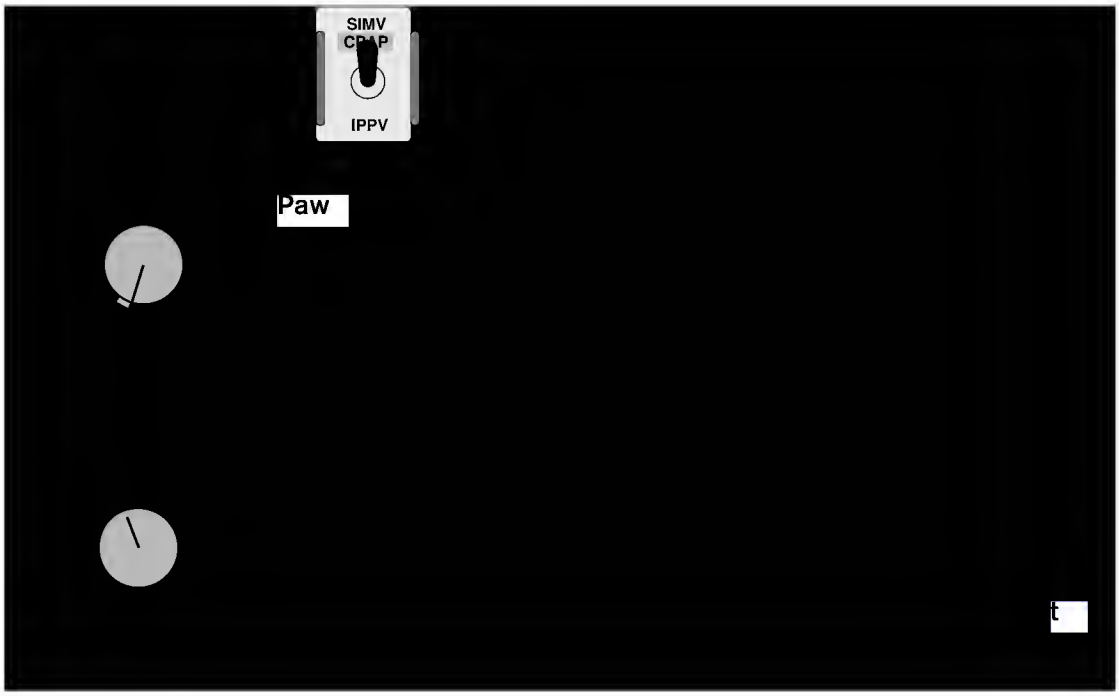

Fig. 11: CPAP

Setting of a continuous positive pressure in the lung: CPAP.

Apnea Monitoring and Apnea Ventilation are active.

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1.4.1 CPAP/ASB (Pressure Assisted Spontaneous Breathing)

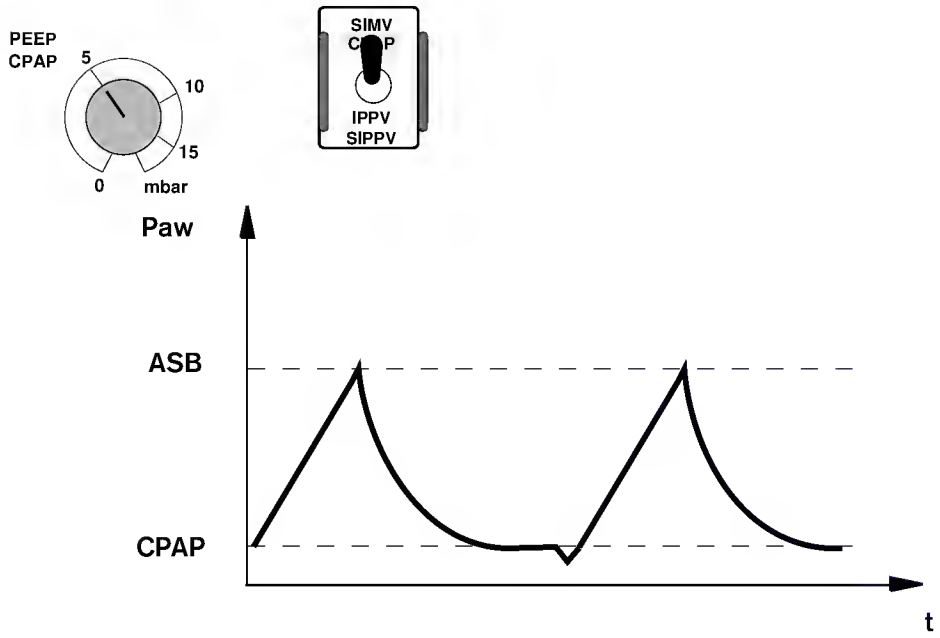

Fig. 12: CPAP/ASB

Set the frequency on the MicroVent to 0 min^{-1} and the ASB pressure higher than the CPAP pressure. This will activate the apnea ventilation and the apnea monitoring. If the ASB pressure is not reached within 4 seconds (for example, due to a leakage) the ASB function will stop. If the ASB function stops three times in a row, then an alarm will be generated (ASB > 4 sec).

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1.4.2 CPAP Reduction

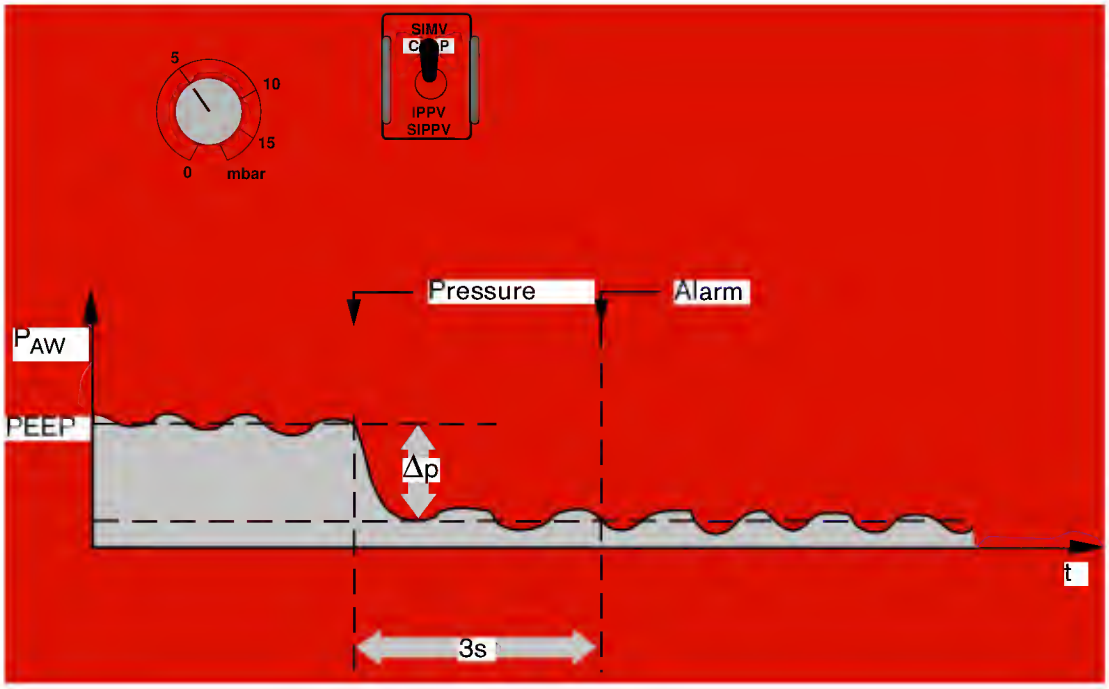

Fig. 13: CPAP Reduction alarm

A drop in pressure of $\Delta p > 5$ mbar within 3 s activates the “CPAP reduction” alarm.

Possible causes:

- Leakage
- Aspiration
- Unintentional adjustment
- Intentional change in CPAP

Visual and acoustic alarms are given after 15 s.

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1.4.3 Apnea Ventilation (Monitoring of Spontaneous Breathing)

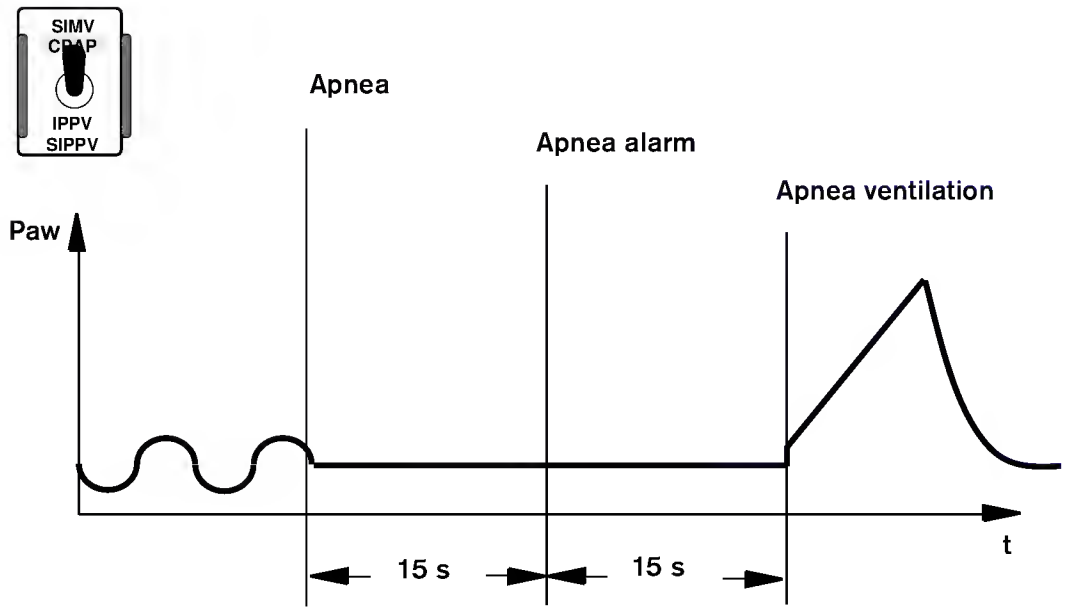

Fig. 14: Apnea ventilation

An alarm will be triggered after 15 seconds starting from detection of apnea. After another 15 seconds, apnea ventilation will be activated.

The apnea ventilation parameters result from the set parameters V_T and T_{insp}, the fixed SIMV values, and the 8 min^{-1} frequency.

Apnea ventilation can be deactivated by pressing the Reset button or by setting the frequency to a value higher than 2 min^{-1}.

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1.5 Display

Overview

Measured value display

Tabelle 1:

IPPV	SIPPV	SIMV	CPAP
IPPV -> SIPPV?	SIPPV -> IPPV?	–	–
Ti:Te	–	–	–
Flow	Flow	Flow	–
Peak	Peak	Peak	Peak
Mean	Mean	Mean	Mean
PEEP	PEEP	PEEP	CPAP
–	Frequency	Frequency	Frequency
–	–	VT exsp.	VT exsp.
–	–	–	Apnea ventilation

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Alarms/info

Tabelle 2:

IPPV	SIPPV	SIMV	CPAP	Apnea ventilation
Paw high	Paw high	Paw high	Paw high	Paw high
Paw low	Paw low	Paw low	Paw low	Paw low
PEEP high	PEEP high	PEEP high	PEEP high	PEEP high
Leakage	Leakage	Leakage	–	–
–	–	Apnea	Apnea	–
–	–	–	CPAP reduction	–
MV high	MV high	MV high	MV high	–
MV low	MV low	MV low	MV low	–
–	–	ASB > 4 s	ASB > 4 s	–

General info
Mains failure
Low supply pressure
Incorrect setting

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2 Functional Diagram

2.1 SW Version 1.10

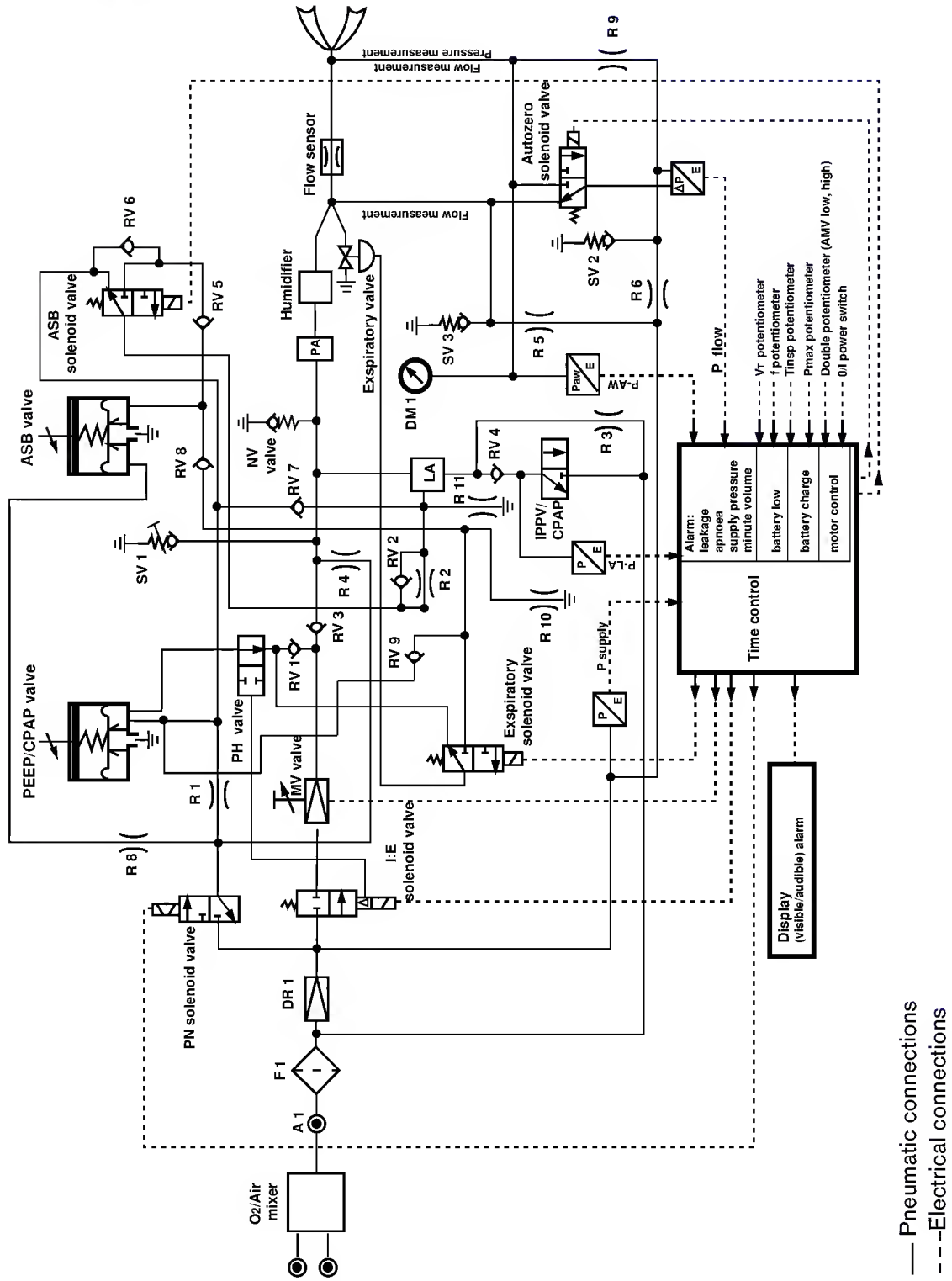

Fig. 15: Functional diagram of the MicroVent SW Version 1.10

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2.2 SW Version 1.21

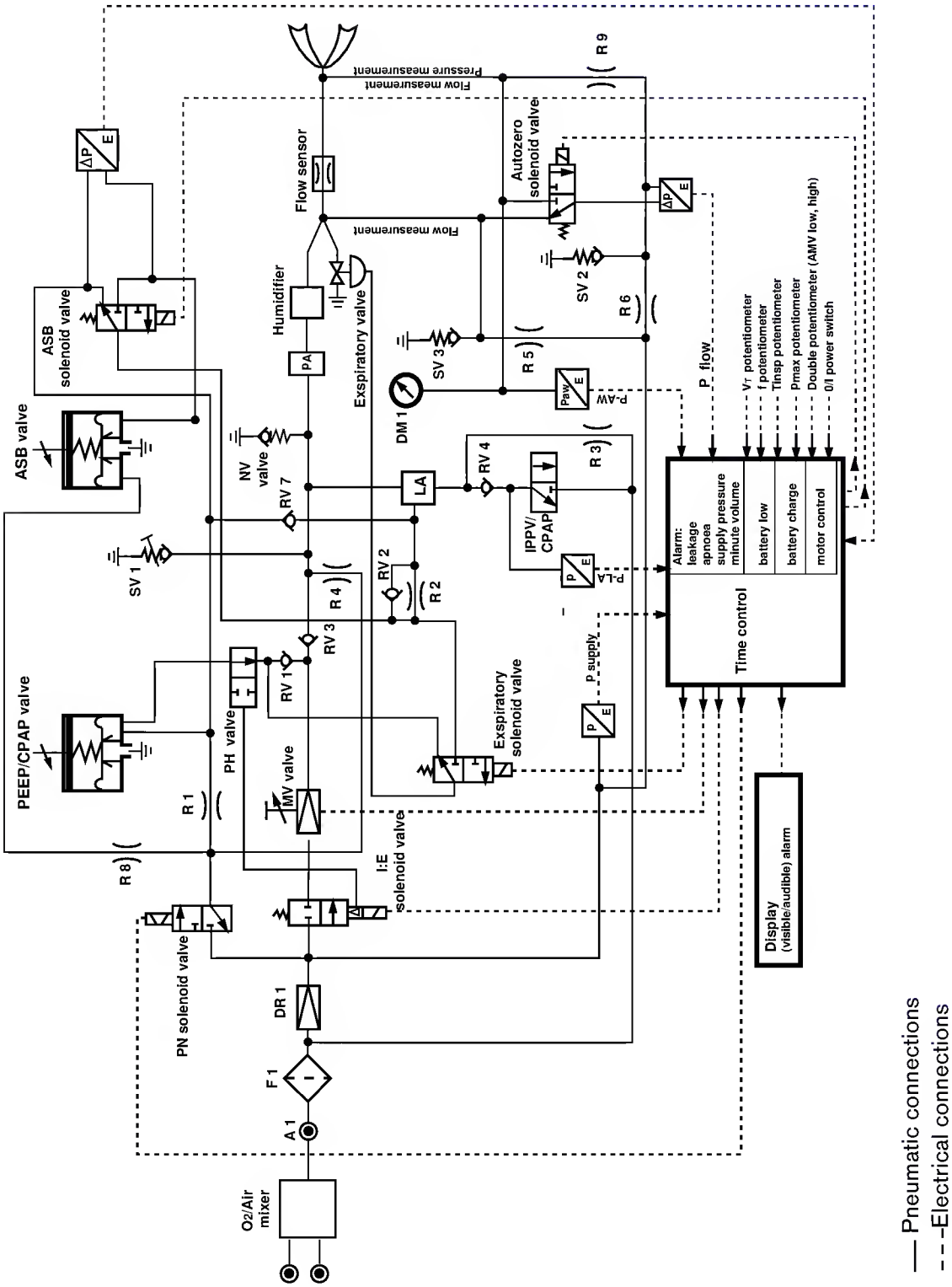

Fig. 16: Functional diagram of the MicroVent SW Version 1.21

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2.3 Legend to the Functional Diagram

O2/Air mixer	Compressed air/oxygen mixer
A 1	MicroVent wall supply connection
F 1	Filter
DR1	Pressure regulator
PN solenoid valve	Bistable PEEP-ZERO solenoid valve
I:E solenoid valve	Monostable solenoid valve
ASB solenoid valve	Monostable solenoid valve
Exp. solenoid valve	Monostable solenoid valve
Autozero solenoid valve	Monostable solenoid valve
MV valve	Minute volume valve (electrical/pneumatic)
PH valve	PEEP-HIGH changeover valve (pneumatic)
PEEP/CPAP valve	PEEP valve (pneumatic)
ASB valve	ASB valve (pneumatic)
Expiratory valve	Expiratory valve (pneumatic)
IPPV/CPAP	IPPV/CPAP mode switch
SV 1	Safety valve 60 to 80 mbar
SV 2	Safety valve, 80 mbar
SV 3	Safety valve, 80 mbar
NV valve	Emergency air valve, 0 to 5 mbar
DM 1	Manometer
PA	Patient connection
LA	Lung demand valve
R 1	Restrictor, 0.55 L/min (2.5 bar)
R 2	Restrictor, 0.5 L/min (1.0 bar) SW 1.10; 0.7 L/min (2.0 bar) SW 1.21
R 3	Restrictor diameter 0.42 mm
R 4	Restrictor, 6 L/min (2 bar)
R 5	Restrictor, 0.08 L/min (2.0 bar)
R 6	Restrictor, 0.08 L/min (2.0 bar)
R 8	Restrictor, 0.55 L/min (2.5 bar)
R 9	Restrictor, 1.15 L/min (0.5 bar)
R 10	Restrictor, 2.0 L/min (2 bar)
R 11	Restrictor, 0.2 L/min (2 bar)
RV 1	Check valve
RV 2	Check valve
RV 3	Check valve
RV 4	Check valve
RV 5	Check valve
RV 6	Check valve
RV 7	Check valve
RV 8	Check valve
RV 9	Check valve

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P/E (P-supply)	Supply pressure sensor
P/E (P-LA)	Lung demand valve pressure sensor
Paw/E (P-AW)	Airway pressure sensor
ΔP/E (P-flow)	Differential pressure sensor
ΔP/E	Pressure switch PEEP-ASB
Flow sensor	Flow sensor
Time control	Control PCB
Potentiometer	Front panel
Display	
O/| power switch	
Humidifier	

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3 Gas Flow in the MicroVent

A functional diagram is at hand for software version 1.10 to assist in describing the MicroVent gas flow. In those places where it is necessary, software version 1.21 (and all higher versions) will be gone into in more detail.

3.1 Gas Supply Connected, MicroVent Switched Off

First pathway of the gas: the air/oxygen mixture from the mixer flows through the wall supply connection of the MicroVent A 1 and through the filter F 1 to the pressure regulator DR 1. The pressure regulator DR 1 reduces the gas pressure to a constant pressure of 1.6 bar (at a flow of 40 L/min). This pressure is available at the PN solenoid valve, at the I:E solenoid valve, at the P/E pressure sensor (P-supply) and at the restrictors R 5 and R 6. The restrictors R 5 and R 6 provide a purge flow which avoids buildup of humidity during the differential pressure measurement.

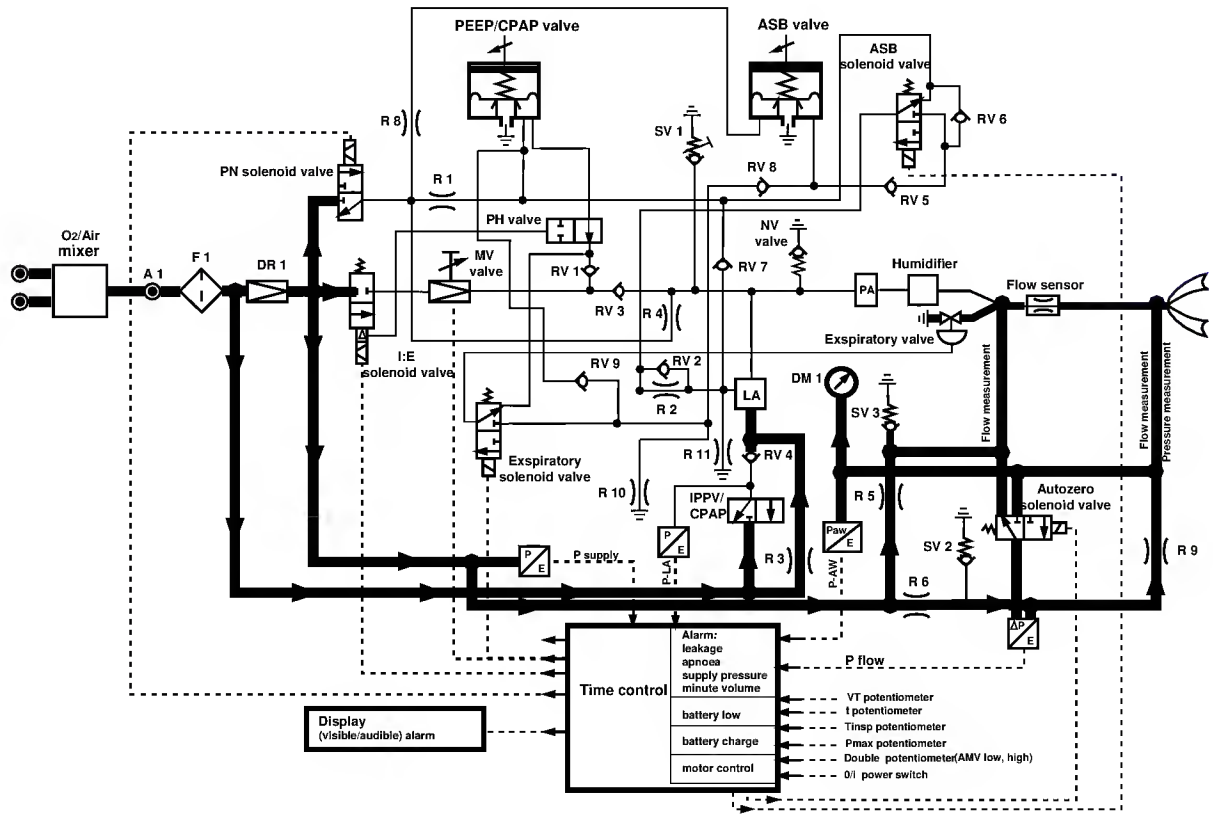

Fig. 17: Gas supply connected, MicroVent switched off

The second pathway of the gas starts between the filter F 1 and the pressure regulator DR 1. This gas (control pressure) flows to the IPPV/CPAP mode switch and, via the restrictor R 3, to the lung demand valve LA.

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3.2 MicroVent Switched On, IPPV, Inspiratory Phase

When switching on the MicroVent, the PN solenoid valve is triggered. The PN solenoid valve opens and remains in this position until the MicroVent is switched off. The gas flows through the PN solenoid valve and the restrictor R 1 to the PEEP control system.

In addition, the gas flows through the restrictor R 4 into the inspiratory branch. This constant flow through the restrictor R4 of approx. 5 L/min is referred to as the basic flow. It is used to assist spontaneous breathing and for flushing purposes to eliminate the patient's CO2. The basic flow is always active when the unit is switched on.

The I:E solenoid valve is triggered and opens. The gas flows to the PH valve and closes the connection to the PEEP/CPAP valve. At the same time, the gas flows to the minute volume valve MV which adjusts according to the preselected values (VT, Tinsp). The gas flows through the check valve RV 3, the patient connection PA, the humidifier, and the flow sensor to the patient. The gas also flows through the check valve RV 1 to the expiratory solenoid valve. From here, the gas flows to the expiratory valve and closes the expiratory path to atmosphere.

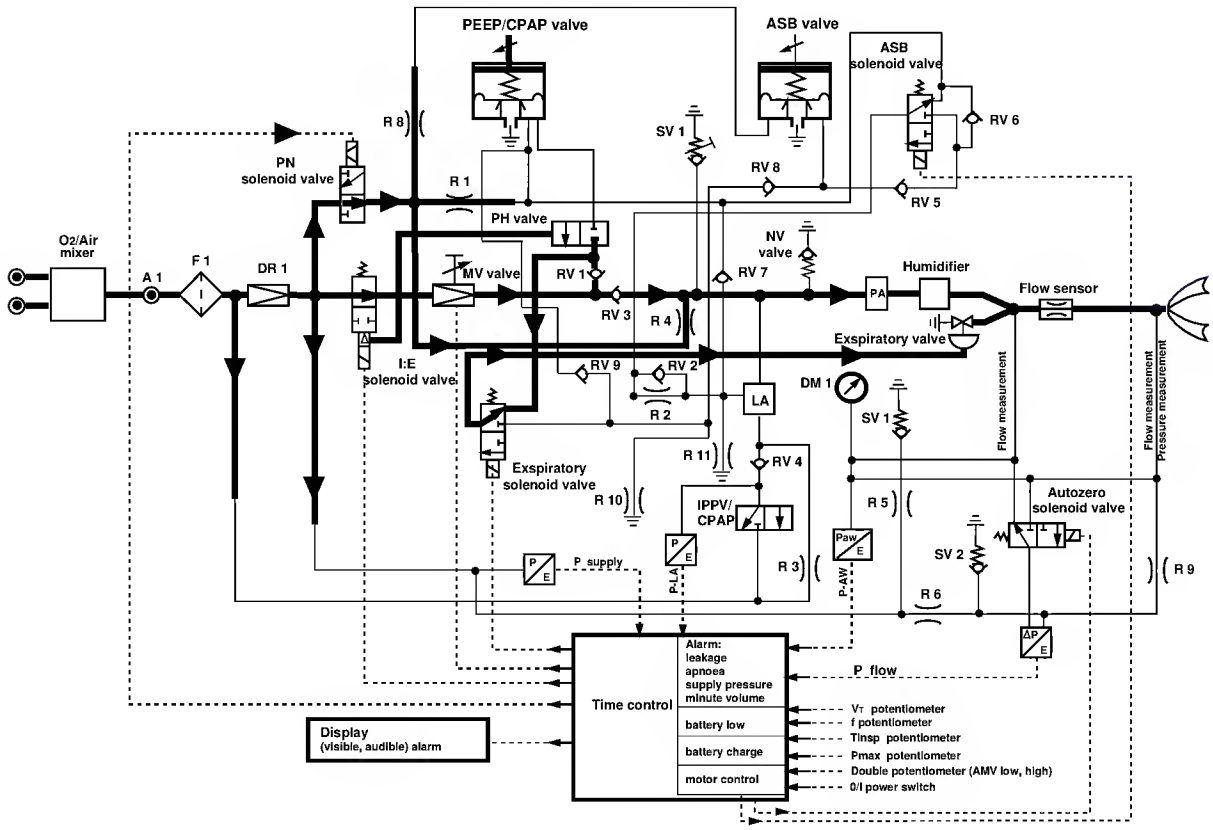

Fig. 18: IPPV, inspiratory phase

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3.3 IPPV, Expiratory Phase

The I:E solenoid valve is switched off after the inspiratory time (Tinsp) is over. The PH valve is relieved on the control side and switched over. This applies the PEEP control pressure to the PEEP/CPAP valve. The PEEP control pressure is vented to atmosphere. The patient can breathe out to atmosphere via the flow sensor and the expiratory valve. The expiratory flow is measured by the flow sensor, then converted to minute volume, and finally shown on the display.

Fig. 19: IPPV, expiratory phase

To minimize the influence of humidity on flow measurement in the breathing system a purge flow is admitted into the system upstream and downstream of the flow sensor. The gas flows through the restrictors R 5 and R 6 into the system. The safety valves SV 2 and SV 3 reduce excessive pressure (> 80 mbar) and thus avoid damage to the differential pressure sensor ΔP/E (P-flow).

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3.3.1 IPPV, Expiratory Phase with PEEP > 0 mbar

When the PEEP/CPAP valve is set to > 0 mbar, a spring force acts on the diaphragm of the PEEP/CPAP valve. This means, during expiration, the PEEP pressure of the expiratory valve can be vented to atmosphere only up to the adjusted PEEP value.

In order to stabilize the set PEEP value and to dampen the system, a defined flow is allowed to enter into the PEEP control system through the restrictor R 4. The patient can only breathe out up to the set PEEP control pressure, i.e. a residual pressure (PEEP) remains in the lungs.

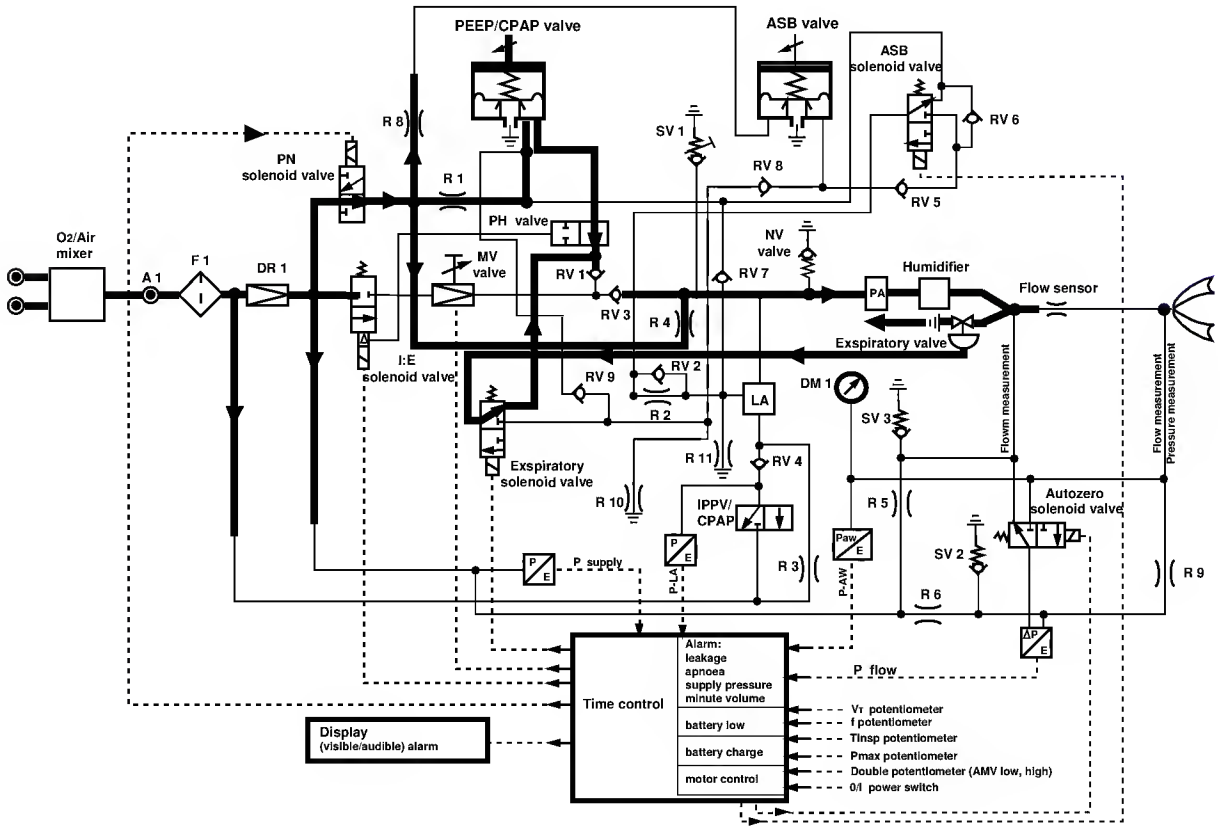

Fig. 20: IPPV, expiration with PEEP

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3.4 SIPPV (Synchronized IPPV)

SIPPV is a controlled ventilation mode in which the mandatory breath is triggered by the patient. The mode switch is set to IPPV/SIPPV. The SIPPV mode is activated from the menu. A mandatory breath is delivered when the flow sensor detects that the patient has inspired a flow of at least 3 L/min.

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3.5 Basic Flow

The basic flow is activated when the MicroVent is switched on. It is used to assist spontaneous breathing. The basic flow also flushes the connectors during expiration to eliminate the gas exhaled by the patient which contains CO_2.

Switch-on of the MicroVent actuates the PN solenoid valve. A constant flow of 5 L/min. is then passed to the patient via the restrictor R4.

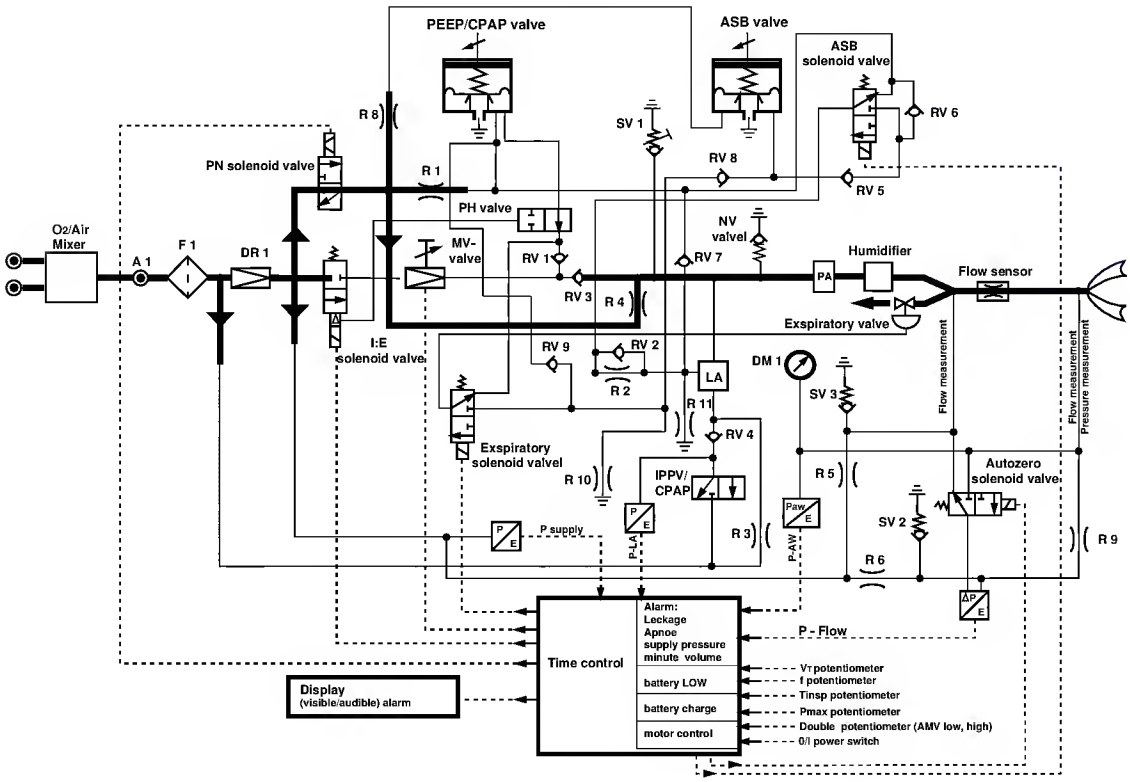

Fig. 21: Basic flow

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3.6 SIMV

3.6.1 SIMV (Synchronised Intermittent Mandatory Ventilation), Inspiration Phase

The mode selector switch is set to SIMV/CPAP and the frequency is set to a value higher than 2 min^{-1}. The inspiration process is the same as described under IPPV. The lung demand valve is ready to deliver but not yet active because of the high airway pressure Paw present during the inspiration phase.

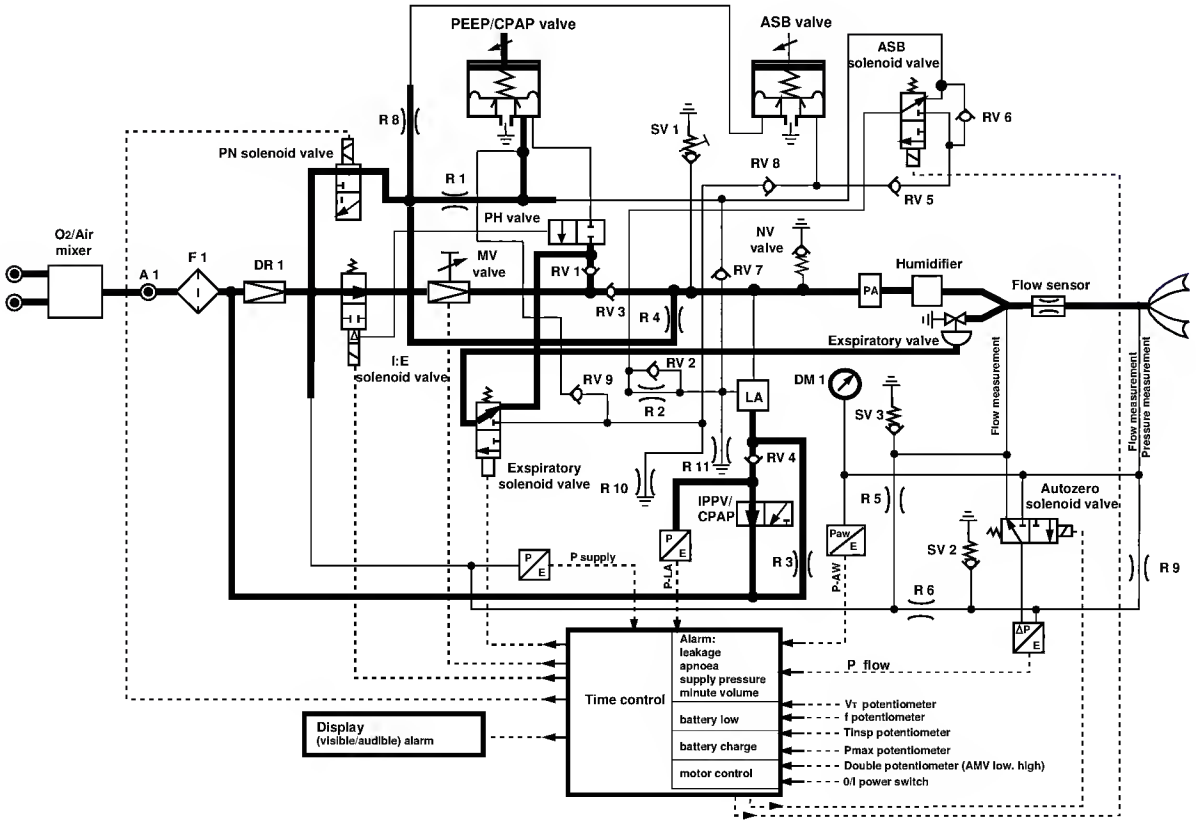

Fig. 22: SIMV (inspiration phase)

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3.6.2 SIMV (Synchronised Intermittent Mandatory Ventilation), Expiration Phase

After the inspiration phase (T_{insp}) is over, the I:E solenoid valve is switched off. The PH valve is depressurized on the control side and switched over. The CPAP pressure reaches the expiratory valve. The pressure in the patient's lungs decreases to the CPAP pressure. The CPAP spontaneous breathing phase in the SIMV mode starts as soon as the pressure is equalized (pressure in the lungs = CPAP pressure). The expiration phase continues as described under CPAP.

In the SIMV mode, a trigger window opens before a new mandatory breath is applied. The trigger window lasts for 5 seconds. If a high SIMV frequency results in the expiration time being less than 5 s, the trigger window will be shortened by T_{insp} + T_{expmin} (T_{expmin} = minimum expiration time of 0.5 s). If the patient triggers a breath within this period, the machine will deliver a mandatory breath. To do so, a flow greater 3 L/min has to be generated.

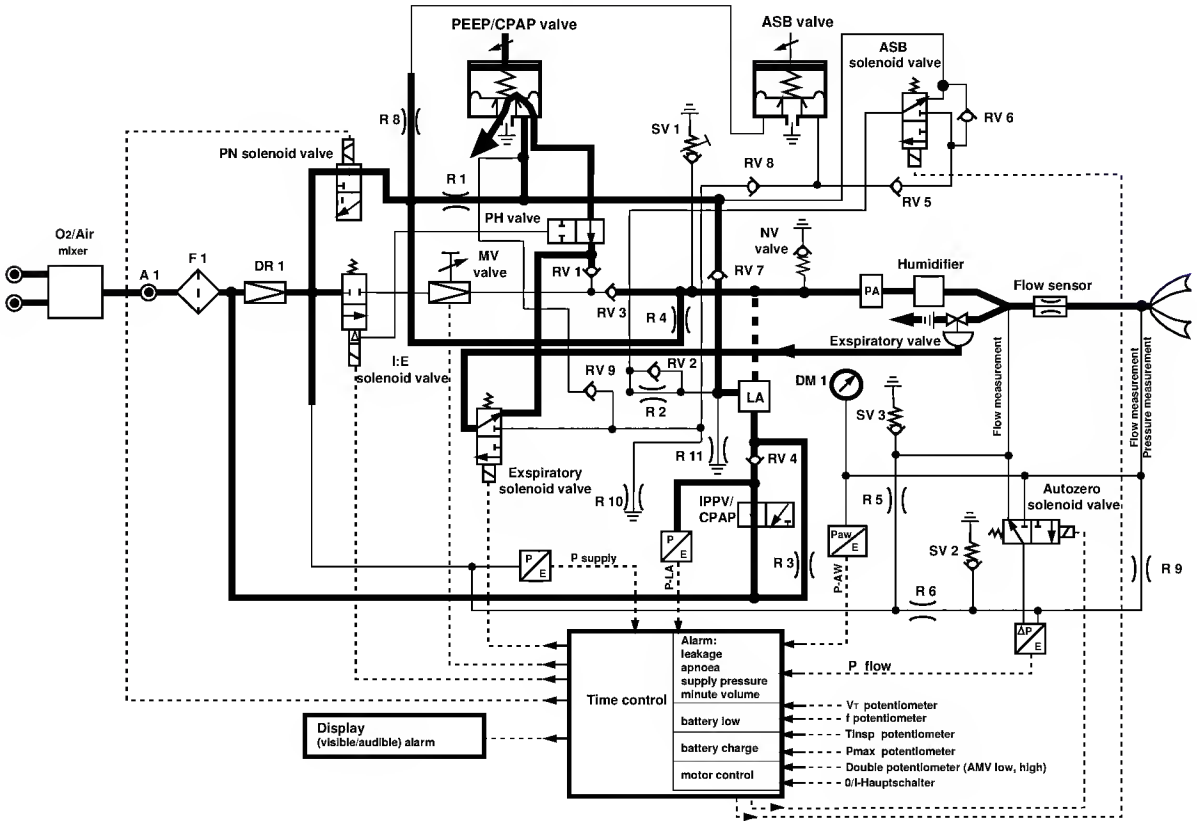

Fig. 23: SIMV (expiration phase)

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3.7 Spontaneous Breathing (CPAP ≥ 3 mbar)

The lung demand valve LA is constantly supplied with gas through the restrictor R 3 (the lung demand valve is precontrolled). This avoids a pressure surge (Paw) when switching over from IPPV to CPAP/SIMV. In order to select the CPAP mode, the mode selector switch must be set to the CPAP/SIMV position. In addition, the frequency must be set to 0 min^{-1}. The lung demand valve LA is supplied with gas through the IPPV/CPAP mode selector switch and the check valve RV 4. This gas is also available at the pressure sensor P-LA which converts the position of the mode selector switch into an electrical signal and transmits this signal to the Control PCB. The delivery performance during the first breath of the lung demand valve LA is attenuated through restrictor R 3 ("LA precontrolled"). R2 and RV2 provide rapid build-up of the control pressure at the lung demand valve but slow dissipation.

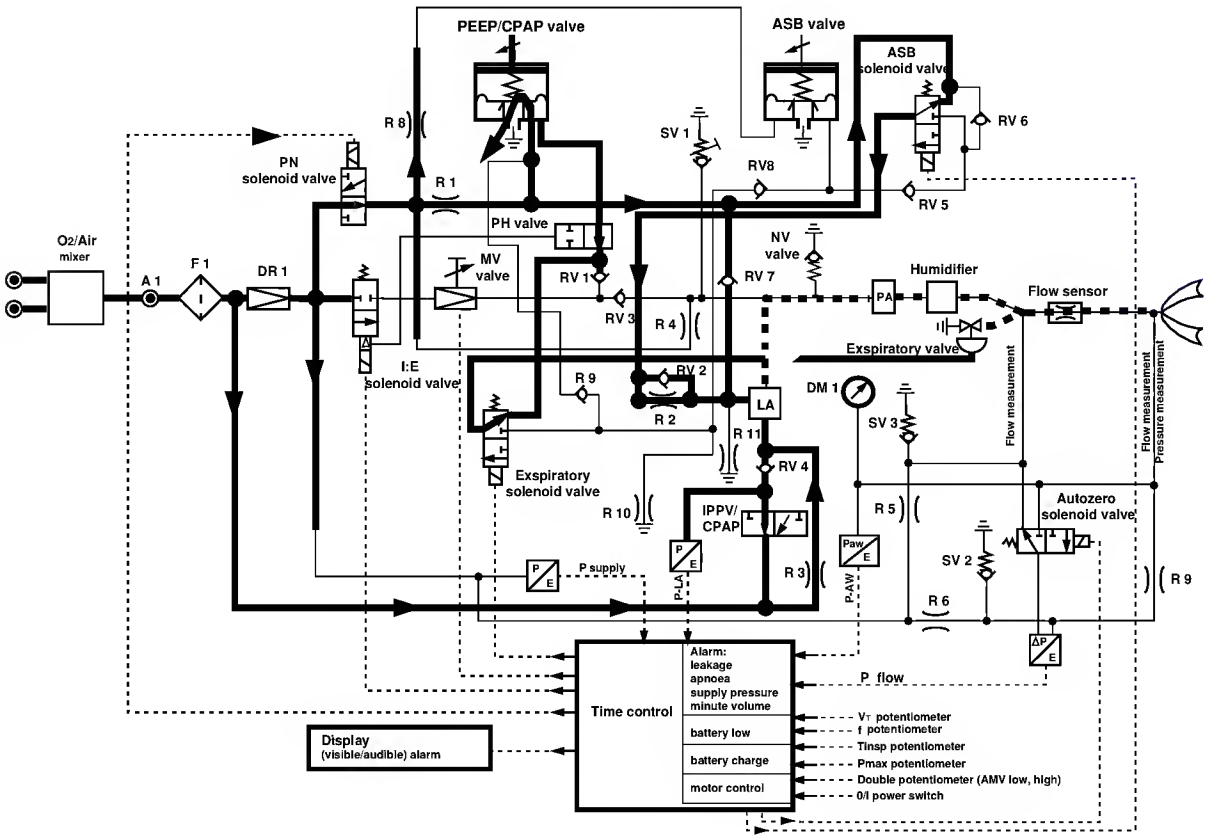

Fig. 24: Spontaneous breathing

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3.8 Spontaneous Breathing (CPAP ≥ 3 mbar, CPAP > ASB)

3.8.1 SW Version 1.10

If the patient's inspiratory effort produces a flow greater than 3 L/min, the ASB solenoid valve and the expiratory solenoid valve will be switched. The CPAP pressure will be admitted to the expiratory valve through RV 9 and the expiratory solenoid valve. The CPAP pressure will be separated from the ASB pressure through RV 8. The lung demand valve (LA) receives the control pressure through RV 7, the RV 6 path and the ASB solenoid valve. RV 5 separates the CPAP and ASB pressures. The control pressures for the lung demand valve and the expiratory valve are separated. As a result, the lung demand valve opens and the pressure in the lungs increases. If the flow decreases to 25% of the previous maximum value, the ASB solenoid valve and the expiratory solenoid valve will be switched back. The CPAP pressure is present at the PH valve, the expiratory solenoid, and the expiratory valve. The restrictors R 10 and R 11 are designed to decrease the control pressures for the lung demand valve and the expiratory valve after switching back.

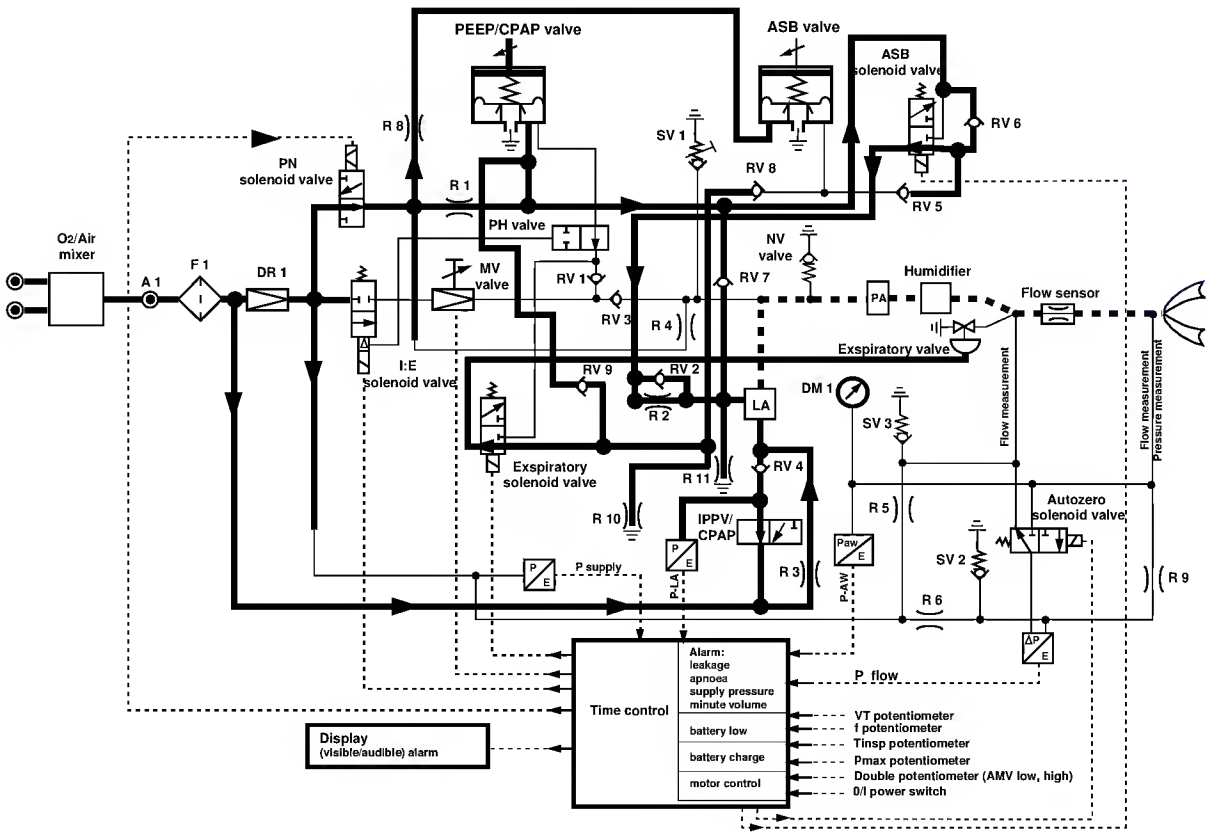

Fig. 25: CPAP > ASB

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3.8.2 Software Version for 1.21 (and higher)

The ASB solenoid and expiration solenoid valves do not switch over during a patient's inhalation attempts if the condition CPAP > ASB is met. CPAP pressure flows through the PH valve and the expiration solenoid valve to the expiration valve. Control pressure is sent to the LA via RV7 and the ASB solenoid valve. Control pressure for the LA and the expiration valve are decoupled.

The LA opens and lung pressure increases. The LA delivers until equilibrium is established via the expiration valve.

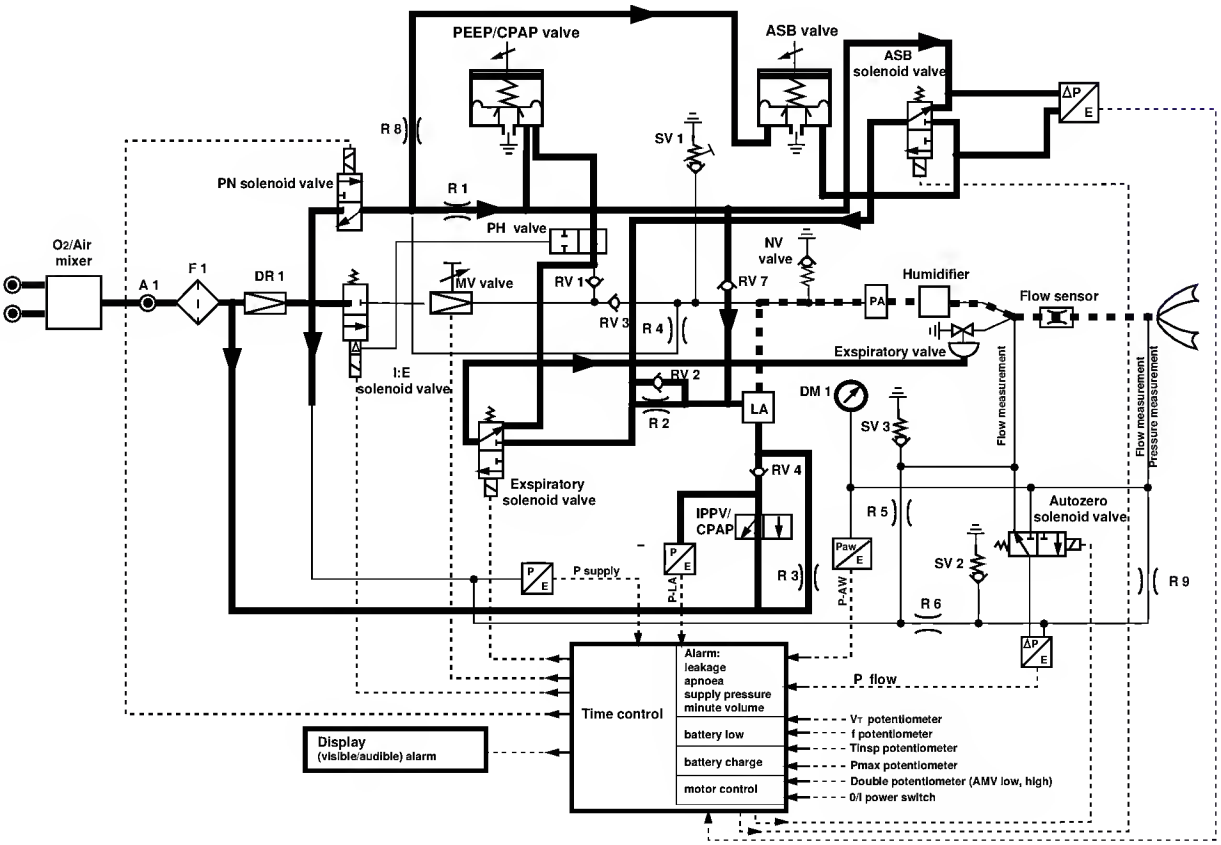

Fig. 26: CPAP > ASB SW-Version 1.21

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3.9 Spontaneous Breathing (CPAP > 3 mbar, CPAP < ASB)

3.9.1 SW Version 1.10

If the patient's inspiratory effort produces a flow greater than 3 L/min, the ASB solenoid valve and the expiratory solenoid valve will be operated. The gas required for the ASB control flows through the restrictor R 8 to the ASB valve. The ASB pressure will be admitted to the expiratory valve through RV 8 and the expiratory solenoid valve. The ASB pressure will be separated from the CPAP pressure through RV 9. The lung demand valve (LA) receives the control pressure through the RV 5 path and the ASB solenoid valve. RV 6 separates the ASB and CPAP pressures. The control pressures for the lung demand valve and the expiratory valve are separated. The lung demand valve opens and the pressure in the lungs increases. The ASB pressure will be switched off as soon as the flow decreases to 25% of the previous maximum flow. The CPAP pressure is then present at the PH valve, the expiratory solenoid valve, and the expiratory valve. The restrictors R 10 and R 11 are designed to decrease the control pressures for the lung demand valve LA and the expiratory valve after switching back.

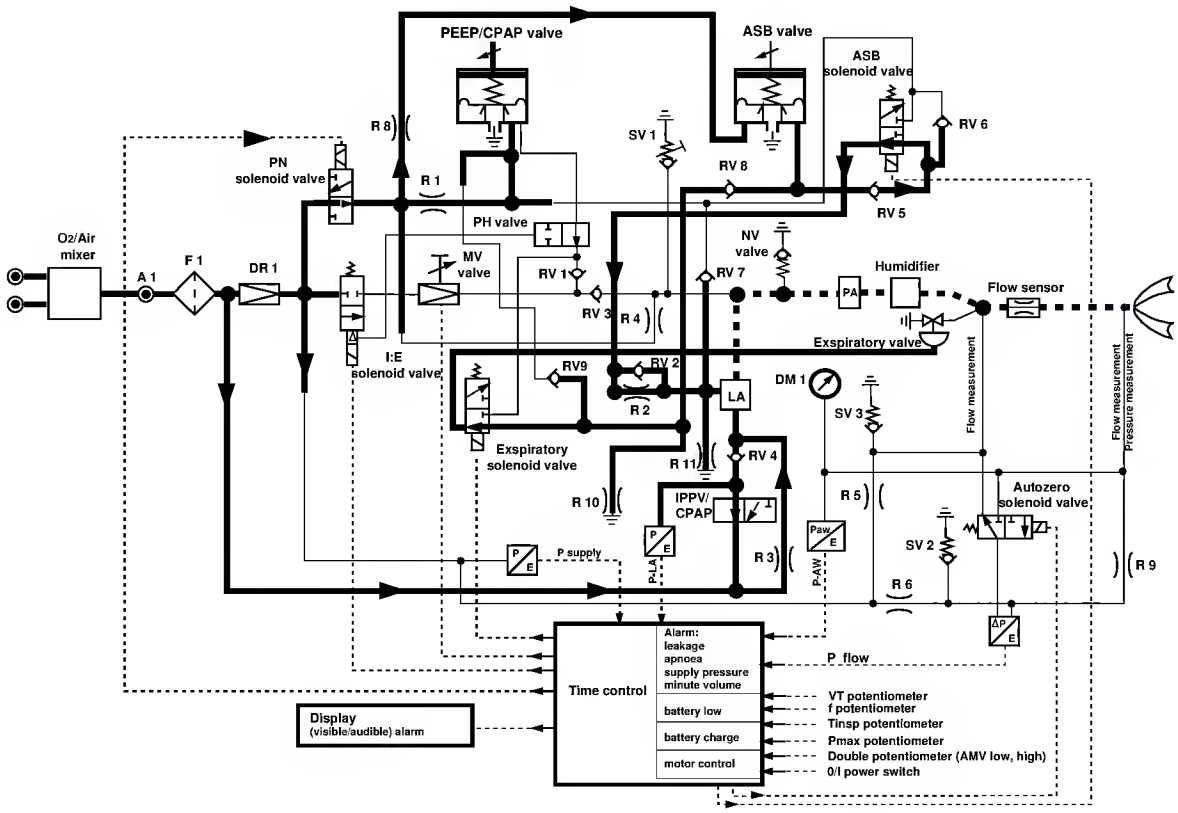

Fig. 27: CPAP < ASB

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3.9.2 Software Version 1.21 or higher

If the patient's inspiratory effort produces a flow greater than 3 L/min and the requirement CPAP < ASB is fulfilled, the ASB solenoid valve and expiratory solenoid valves will switch. The ASB valve is supplied with gas via restrictor R8. ASB pressure is admitted to the expiratory valve through the ASB solenoid and expiratory solenoid valves. Control pressure is supplied to the lung demand valve (LA) through R2 and RV2. The lung demand valve opens and the pressure in the lungs increases.

ASB pressure is switched off as soon as the flow decreases to 25% of the previous maximum flow. CPAP pressure is then available at the PH valve, the expiratory solenoid valve, and the expiratory valve.

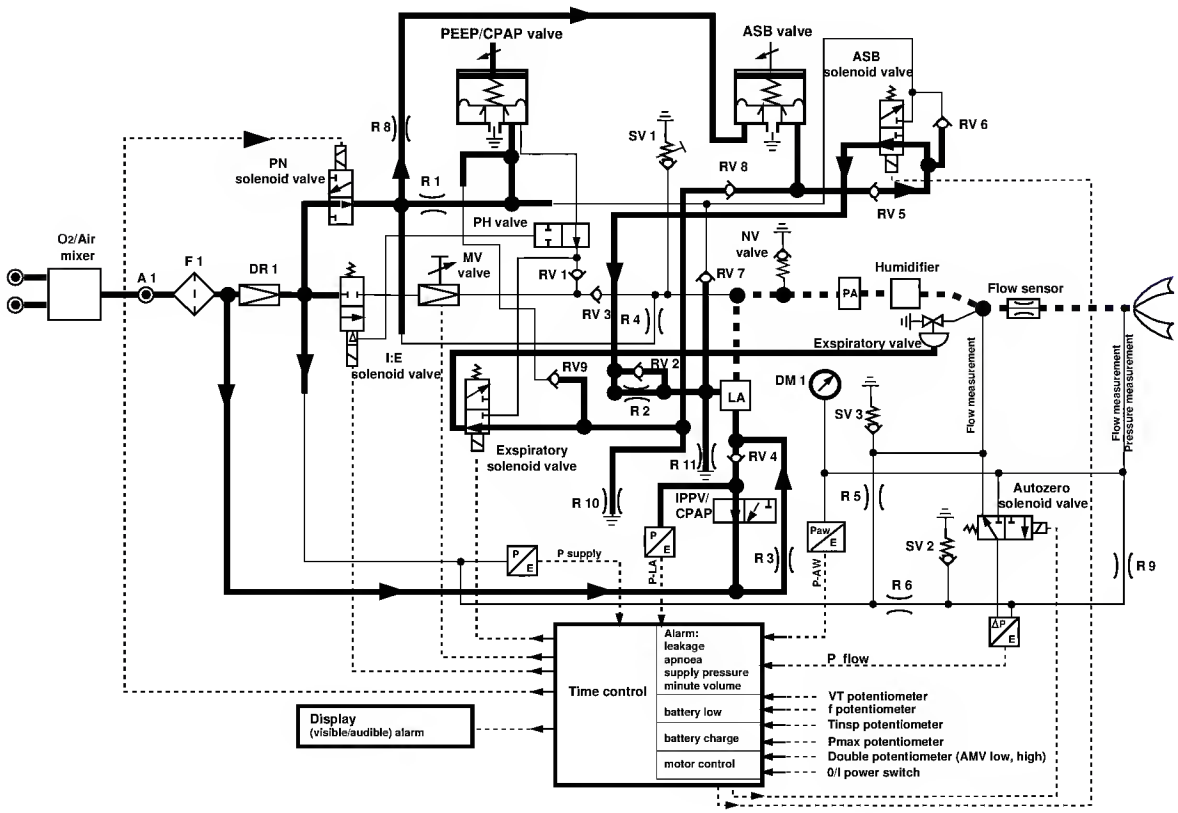

Fig. 28: CPAP < ASB software version 1.21

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3.9.3 Apnea Monitoring and Apnea Ventilation

Spontaneous breathing is monitored by the system. If the flow sensor detects that no changes have occurred at the flow sensor after 15 seconds, a visible and audible alarm is given. After additional 15 seconds, a mandatory breath is applied with the set values.

3.9.4 ASB Termination

If the ASB-pressure is not reached (i.e. leakage) an ASB termination will follow after 4 seconds. Three times in a row generate an alarm “ASB > 4 sec”.

3.9.5 Bypass Over the ASB Solenoid Valve

If the ASB pressure is set below the PEEP/CPAP control pressure, no pressure collapse should occur when the ASB breath is triggered. To achieve this, the bypass RV 6 has been integrated into the path to make sure that at least the PEEP/CPAP control pressure is available. From SW Version 1.21 the bypass RV6 is not in used.

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3.10 Maximum Pressure (Pmax)

The ventilation pressure level is adjusted with the Pmax potentiometer (20–60 mbar). As soon as the Pmax limit is reached, the MicroVent switches over to expiration. The gas flow to the patient is interrupted. The MicroVent no longer applies the gas at a constant volume and the minute volume decreases.

3.11 Safety Valve (SV 1)

If the maximum pressure (Pmax) is exceeded considerably or if the maximum pressure control fails, the ventilation pressure is reduced by an independent mechanical safety valve SV 1. This safety valve is fixed set to an operating pressure of 60–80 mbar.

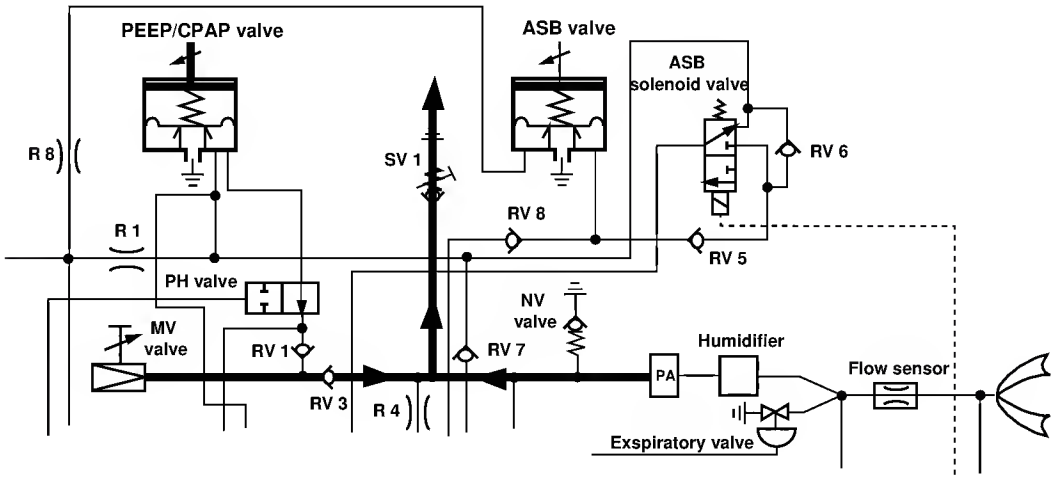

Fig. 29: Safety valve SV 1

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3.12 Emergency Air Valve (NV)

The emergency air valve NV allows the patient to breathe spontaneously (ambient air) in the event that the gas supply fails or the equipment is defective. The opening pressure of the emergency air valve NV lies between 0 and –5 mbar.

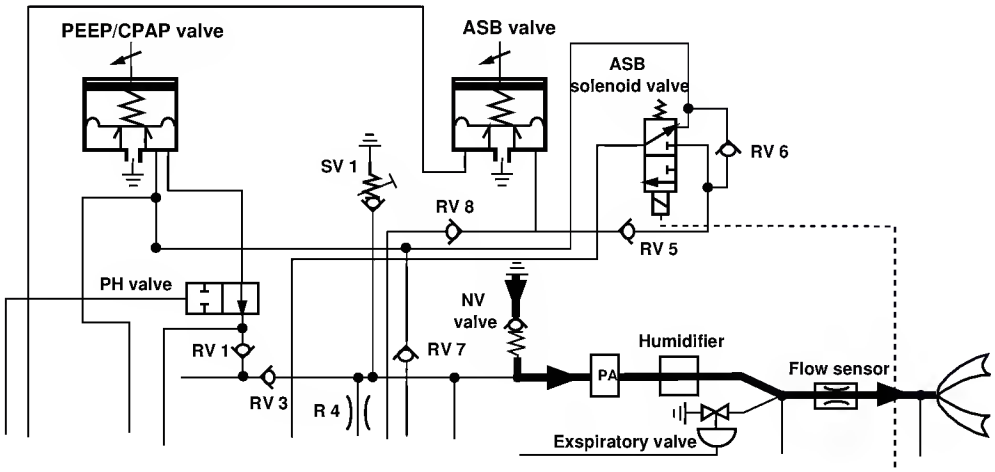

Fig. 30: Emergency air valve NV

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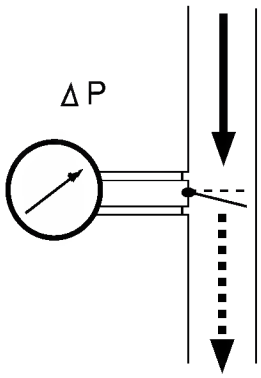
3.13 Flow Measurement

The flow is calculated by the differential pressure sensor ΔP.



ΔP results from the differential pressure (dynamic pressure in measuring lines 1 and 2).

Fig. 31: Flow measurement

The dynamic pressures in the measuring lines 1 and 2 are measured by the differential pressure sensor ΔP/E and processed by the Control PCB. The restrictor R 9 compensates for the resistance of the Autozero valve. The resistance in both tubes must be identical.

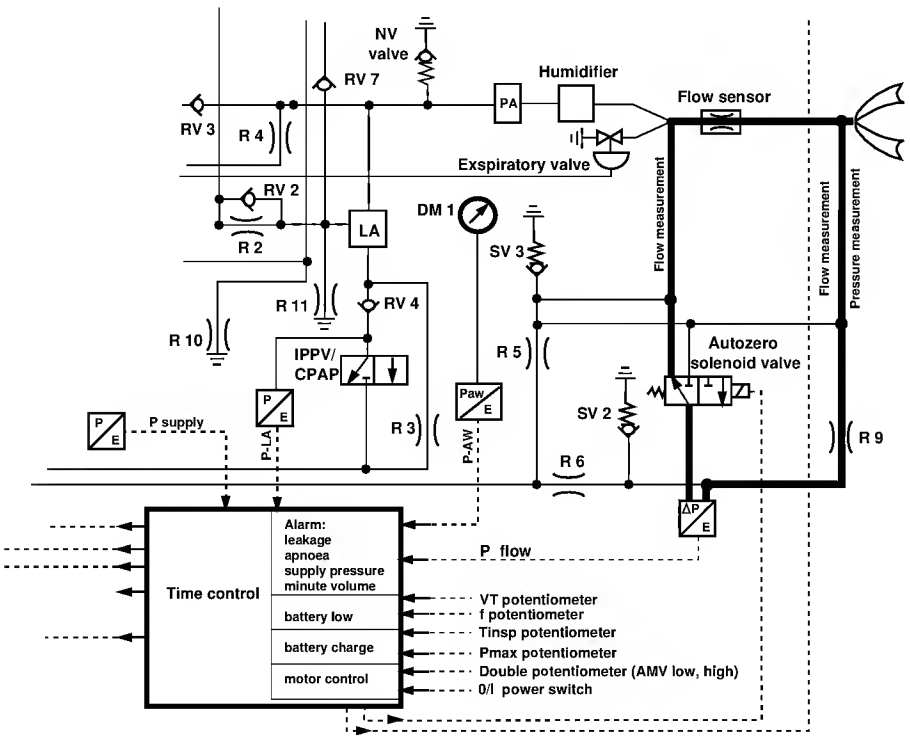


Fig. 32: Flow measurement

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3.14 Autozero

To compensate for a possible drift of the differential pressure sensor ΔP, the sensor is bypassed every 3 minutes via the Autozero valve during expiratory phase. This is done in order to calibrate the sensor.

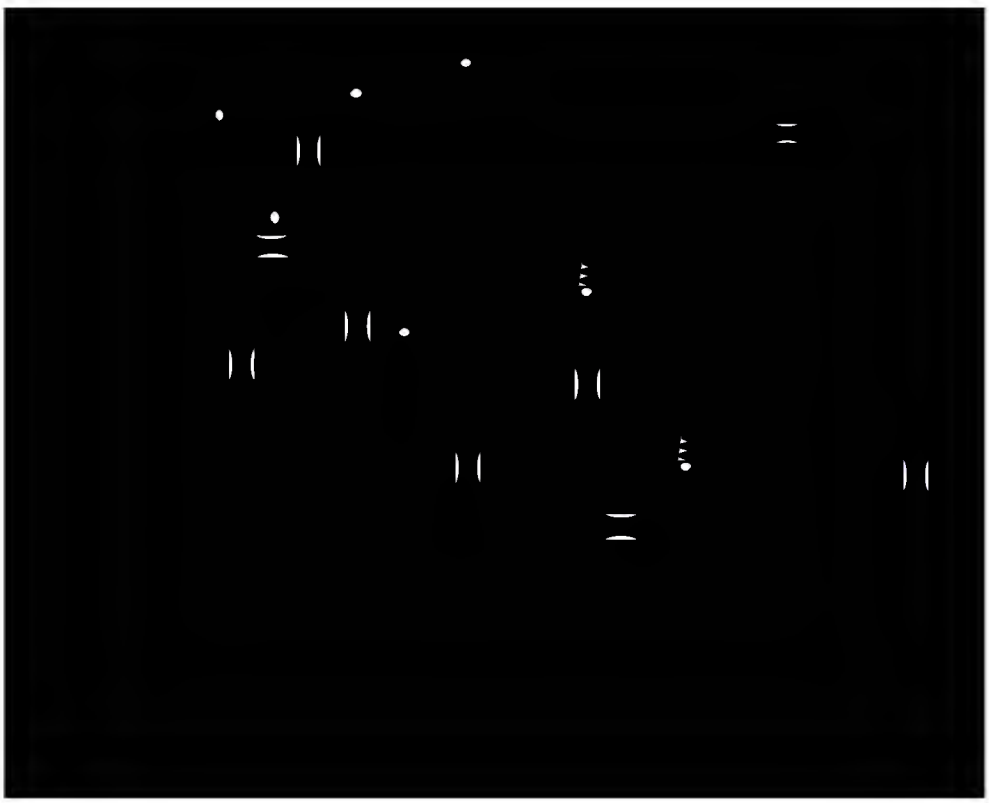

Fig. 33: Autozero

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3.15 Power Supply

The MicroVent is powered either from an internal rechargeable battery pack or an internal non-rechargeable battery pack.

Caution:

To ensure the safety of the patient, the MicroVent must be connected to the power supply unit when used as a stationary unit.

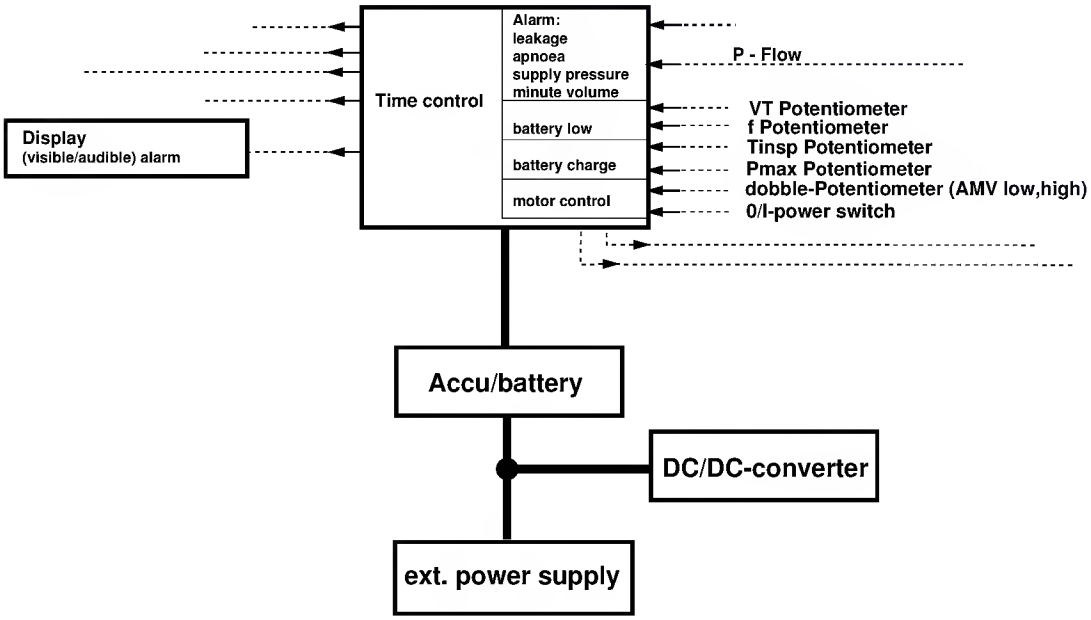

Fig. 34: Power supply

The external power supply powers the MicroVent and, at the same time, charges the internal rechargeable battery pack.

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3.16 Electronics Inputs

The Control PCB processes and monitors the voltages.

The adjusted potentiometer values (VT, frequency, Tinsp, Pmax, MV low/high) as well as the pressure-flow monitoring (P-supply, P-LA, P-AW, P-flow) are read in and monitored, too. From SW Version 1.21 the digital signal of the pressure switch PEEP-ASB are read in.

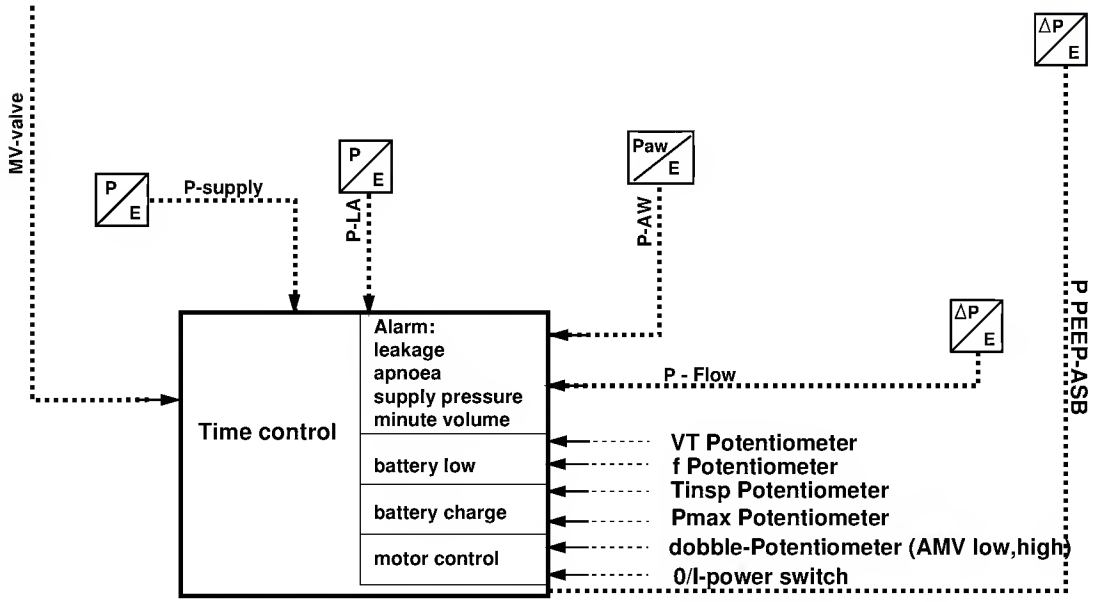

Fig. 35: Electronics inputs

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3.17 Electronics Outputs

Depending on the settings, the valves PN, I:E, MV, Autozero, expiration and ASB are triggered. In addition, the LCD and the buzzer are activated. The minute volume and relevant messages/alarms are displayed.

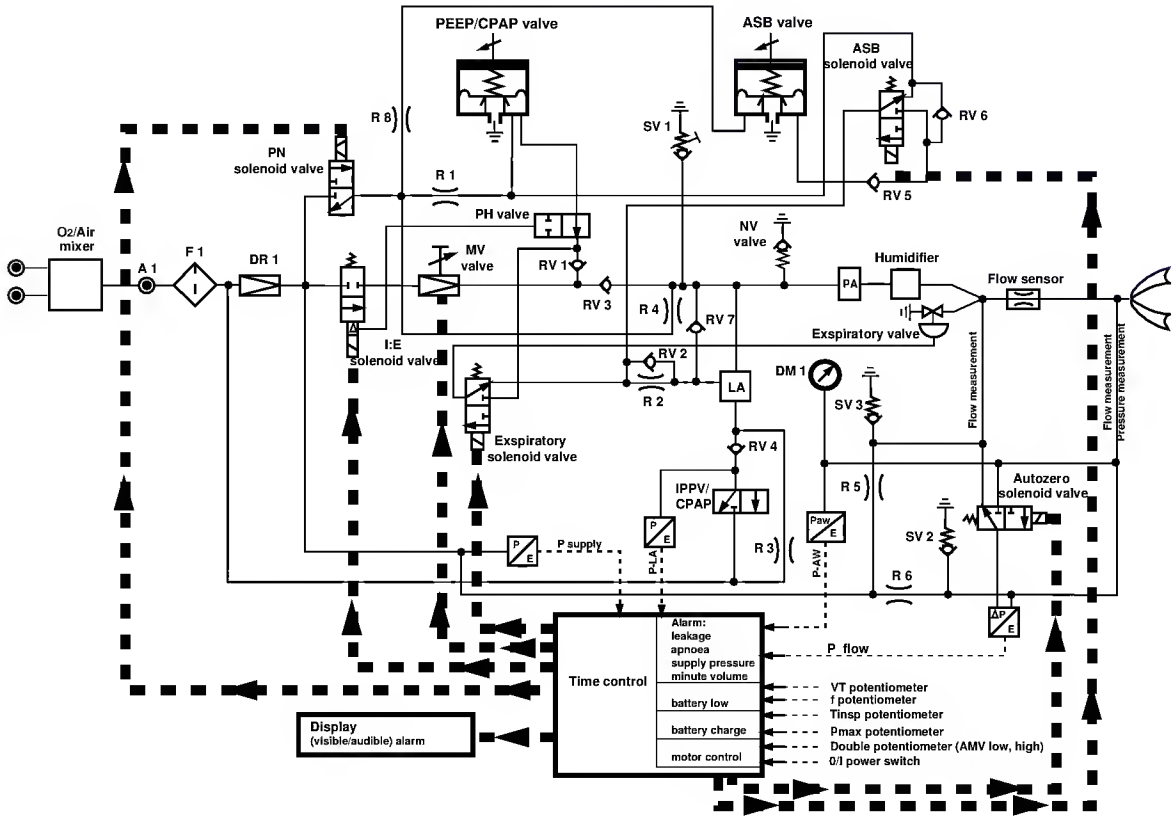

Fig. 36: Electronics outputs

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3.18 Bistable Solenoid Valve

The bistable solenoid valve PN only receives a current pulse of approx. 50 ms when it was switched on or off. This current pulse is designed to set the valve from one stable position into another. This means the valve consumes current only during the switching process.

3.19 Monostable Solenoid Valves

The solenoid valves I:E, ASB, Expiration and Autozero are designed as monostable solenoid valves. They return safely to their normal position as soon as the MicroVent is switched off electrically.

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4 Technical Error (TE) List

Table 3: Possible Errors in the MicroVent

TE no.	Alarm	Cause	Remedy
1	A/D CONVERTER TIMEOUT	Electronics	Replace electronics.
2	CONTR_5 V	Electronics	Replace electronics.
3	POTI MV high	Resistance outside range, cable harness	Check the cable harness and the connector. If necessary, replace the front panel.
4	POTI MV low	Resistance outside range, cable harness	Check the cable harness and the connector. If necessary, replace the front panel.
5	CONTR_VPSWITCH	Electronics	Replace electronics.
6	CONTR_VEXT	Incorrect ext. voltage	Check ext. voltage
7	KEY_LCD_HG	Key sticks	Check, if necessary, replace the front plate
8	KEY RESET	Key sticks	Check, if necessary, replace the front plate
9	BOTH KEYS	Key sticks	Check, if necessary, replace the front plate
11	POTI F	Resistance outside range, cable harness	Check the cable harness and the connector. If necessary, replace the front panel.
12	POTI VT	Resistance outside range, cable harness	Check the cable harness and the connector. If necessary, replace the front panel.
13	POTI Tinsp	Resistance outside range, cable harness	Check the cable harness and the connector. If necessary, replace the front panel.

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Table 3: Possible Errors in the MicroVent

14	POTI_PMAX	Resistance outside range, cable harness	Check the cable harness and the connector. If necessary, replace the front panel.
15	EEPROM WRITE-ERROR	Electronics	Calibrate, otherwise replace electronics.
16	EEPROM CHECKSUM	Electronics	Calibrate, otherwise replace electronics.
17	MV VALVE	MV valve sticks	Check, if necessary, replace the valve
18	POTI_MV	Tolerance	Check, if necessary, replace electronics.
19	SW WATCHDOG	EPROM, electronics	Replace EPROM or electronics.
20	IRAM	Electronics	Replace electronics.
21	XRAM	Electronics	Replace electronics.
22	EPROM	EPROM	Replace EPROM
23	EEPROM PTC ERROR	EEPROM	Replace electronics

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5 Pneumatics Layout Plan

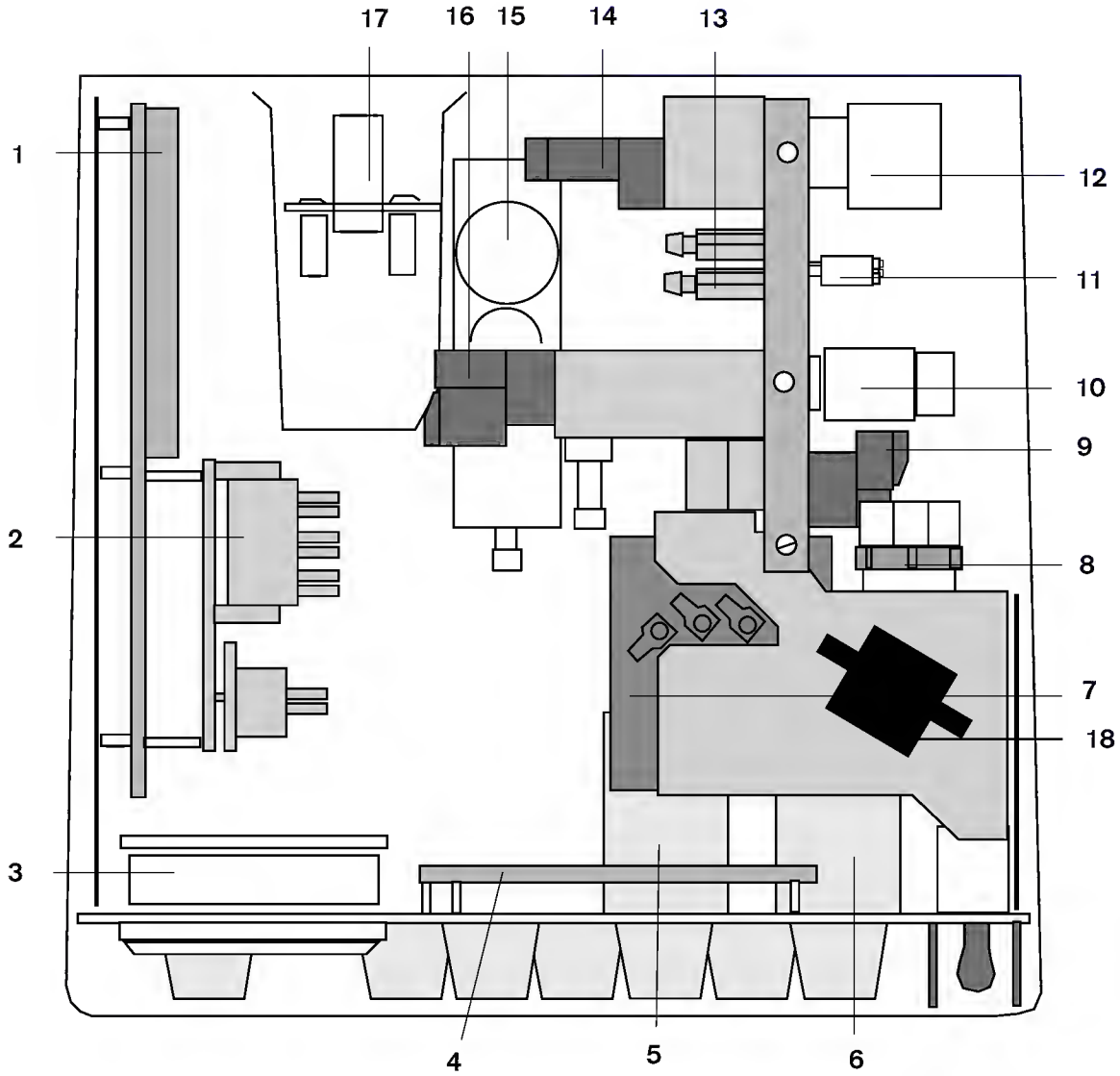

Fig. 37: Pneumatics layout plan

Legend

1 Control PCB
2 Sensor PCB
3 Manometer
4 Display PCB
5 ASB valve
6 PEEP valve
7 I:E solenoid valve, PN solenoid valve
8 Pressure regulator
9 Expiratory solenoid valve (from SW Version 1.21 ASB solenoid valve)
10 MicroVent wall supply connection
11 Flow sensor connectors
12 Patient connection
13 Safety air valve
14 ASB solenoid valve (from SW Version 1.21 Exspiratiory solenoid valve)
15 MV valve
16 Autozero solenoid valve
17 NiCd or AlkMn battery pack
18 Pressure switch PEEP-ASB (from SW version 1.21)

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5.1 PEEP Valve

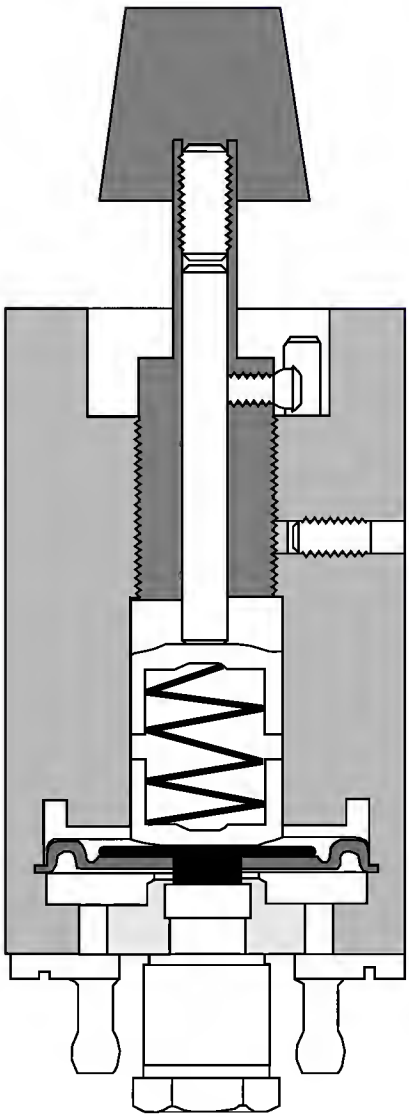

Fig. 38: Sectional view PEEP valve

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5.2 ASB Valve

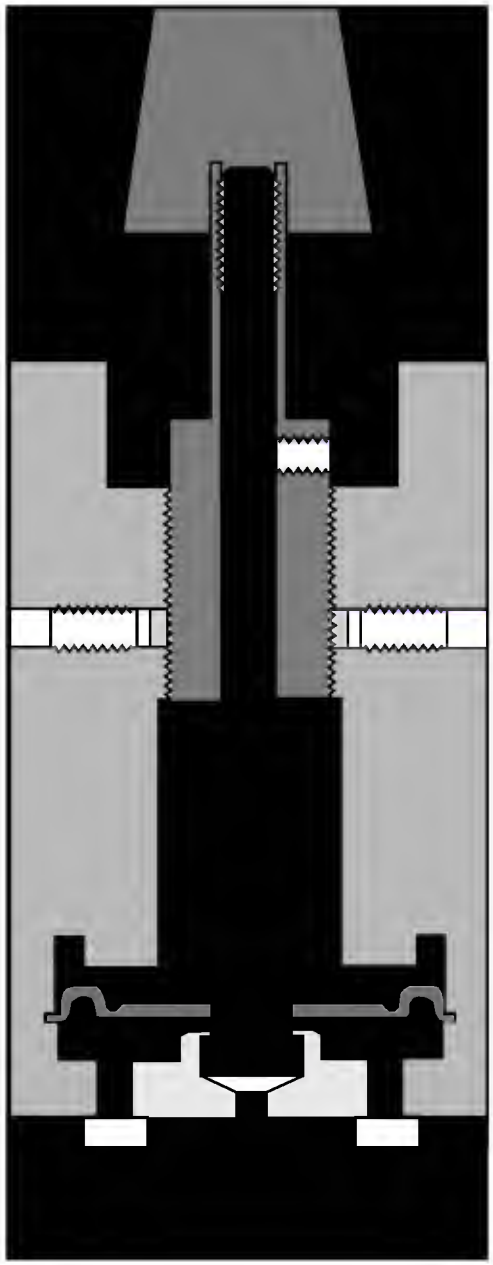

Fig. 39: Sectional view ASB valve

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5.3 Expiratory Valve

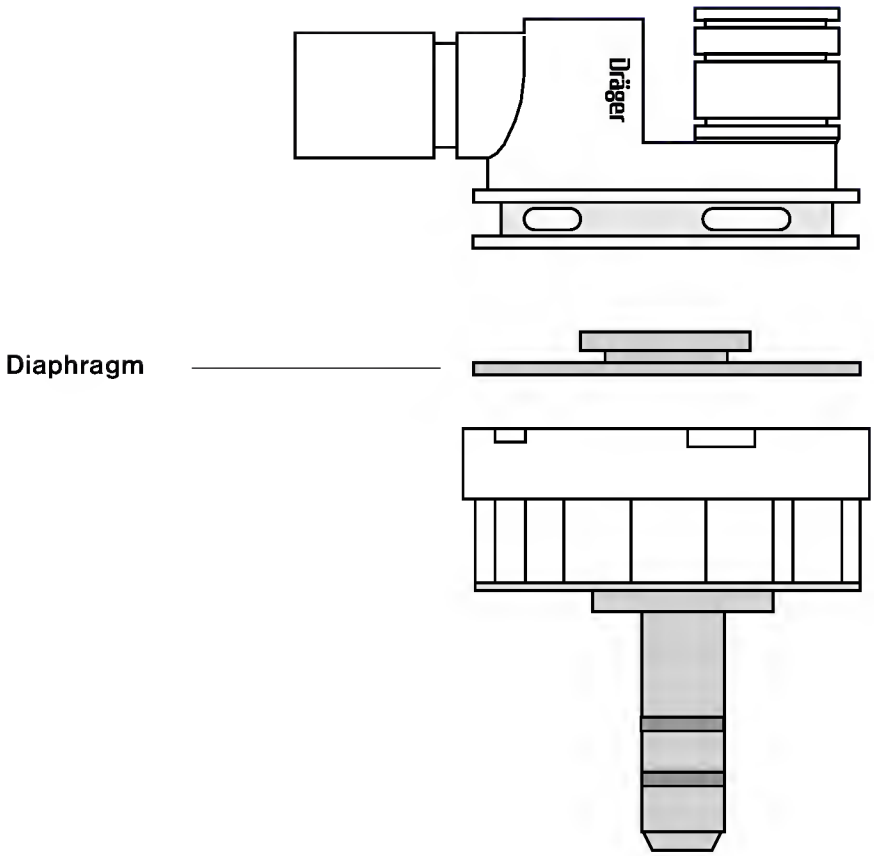

Fig. 40: Expiratory valve

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5.4 Flow Sensor Measurement

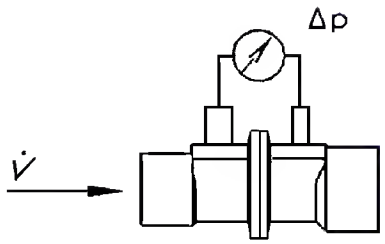
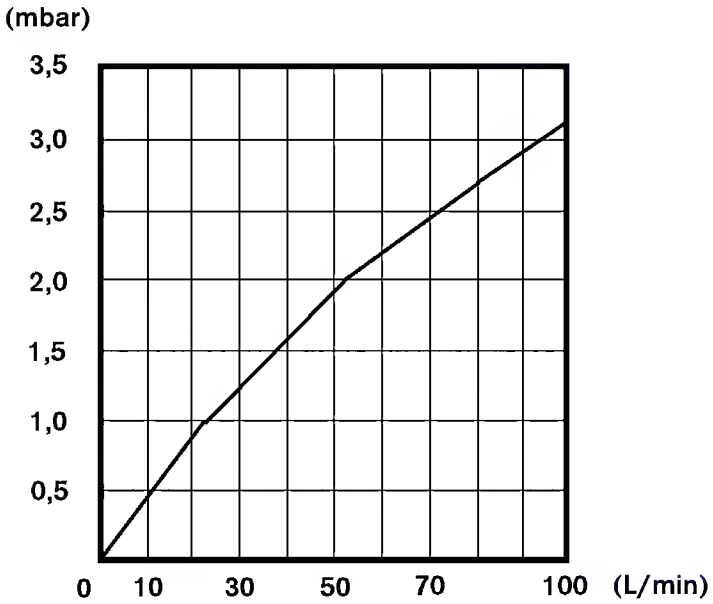


Fig. 41: Flow measurement setup

Flow range: 2 to 120 L

Accuracy: ±12% or ± 1.0 L/min (the higher tolerance value applies)



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5.5 Lung Demand Valve

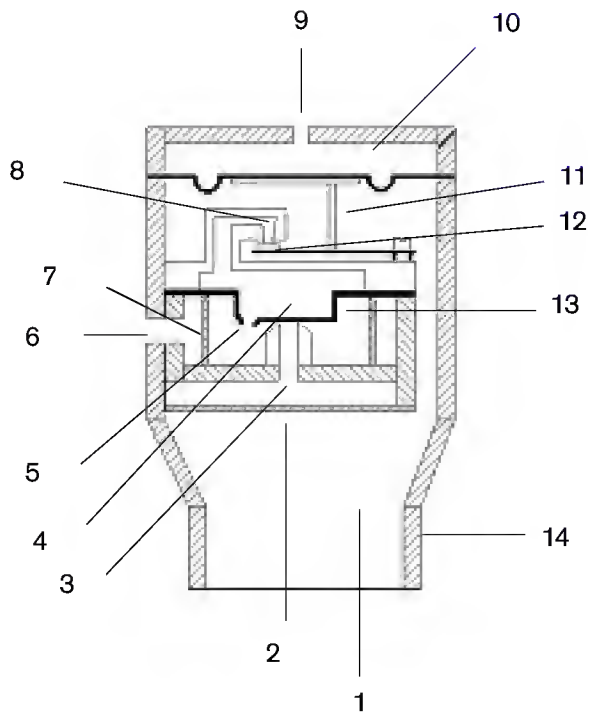

Fig. 42: Sectional view of the lung demand valve

Legend

1	Patient connector	**11**	Connecting rod
2	Sintered filter	**12**	Locking pin
3	Crater	**13**	Control diaphragm
4	Chamber	**14**	Enclosure
5	Inlet port		
6	Control pressure connection		
7	Sintered filter		
8	Port		
9	Connection to the PEEP valve		
10	Control diaphragm		

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5.5.1 Gas Flow in the Lung Demand Valve

The control pressure connection (**6**) is supplied with gas via the R/C element (RV 4 and R 3). The patient connection (**1**) is connected to the patient (PA) via the pneumatics unit. The set PEEP pressure is applied to the control diaphragm (**10**) via the connection to the PEEP valve (**9**).

The inspiratory effort of the pressure generates a negative pressure at the patient connection (**1**). The pressure at the connection to the PEEP valve (**9**) is 0–15 mbar (PEEP).

The control diaphragm (**10**) is pushed down by the inspiratory effort of the patient. When the control diaphragm descends it carries with it the connecting rod (**11**) which pushes the locking pin (**12**) down and opens the port (**8**). The pressure in the chamber (**4**) decreases. The control diaphragm (**13**) moves up and the gas is delivered to the patient through the crater (**3**) and the sintered filter (**2**).

As soon as the patient's inspiratory effort is finished the diaphragm (**10**) moves up and carries with it the connecting rod (**11**) which pulls the locking pin (**12**) up and closes the port (**8**). The pressure in the chamber (**4**) increases and the control diaphragm (**13**) closes the crater (**3**). The gas flow to the patient is interrupted.

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5.6 MV Valve

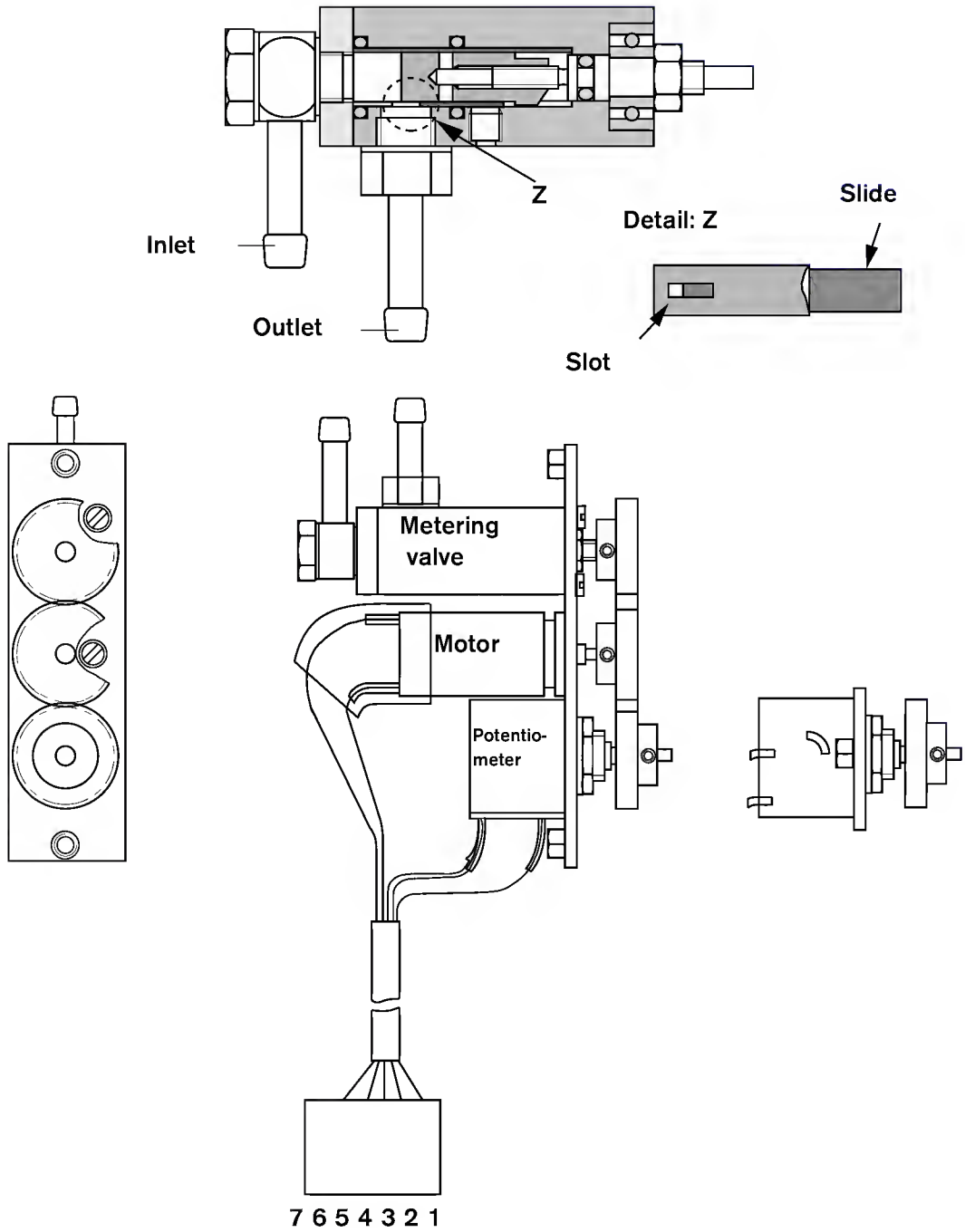

Fig. 43: MV valve

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5.7 Pressure Regulator

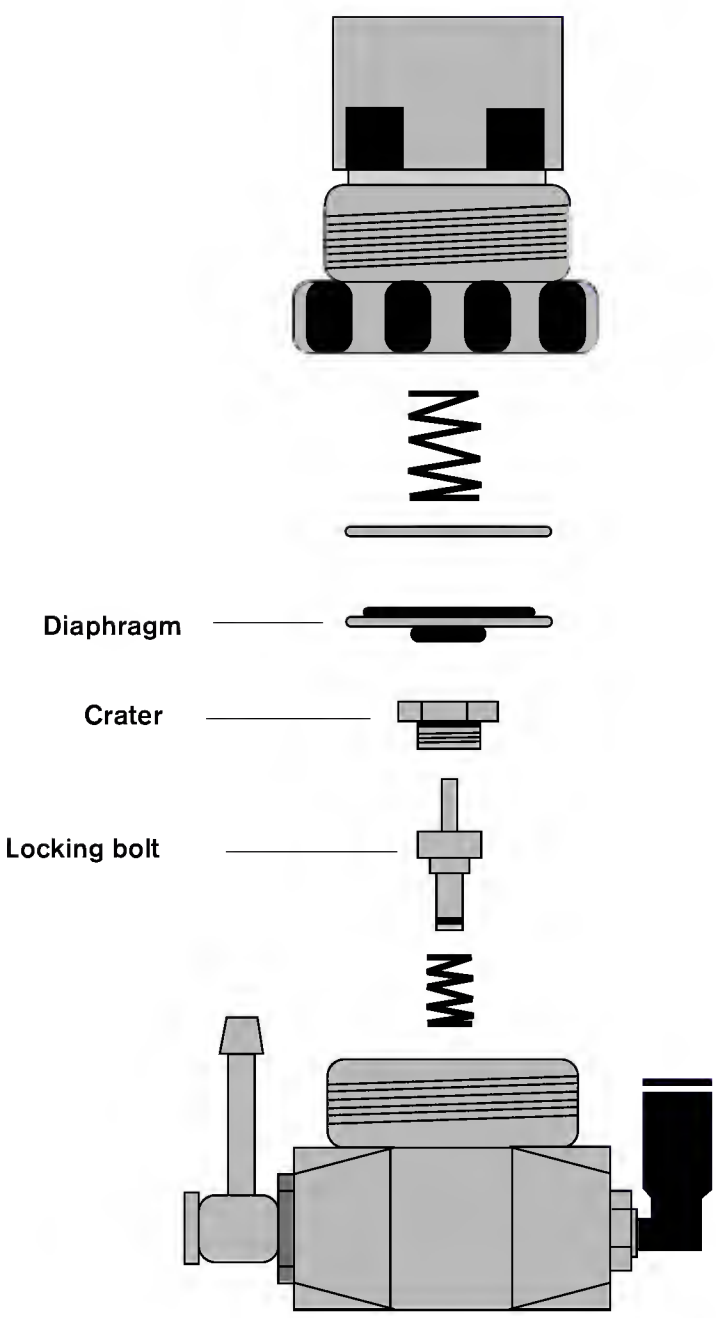

Fig. 44: Pressure regulator

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5.8 Gas Supply

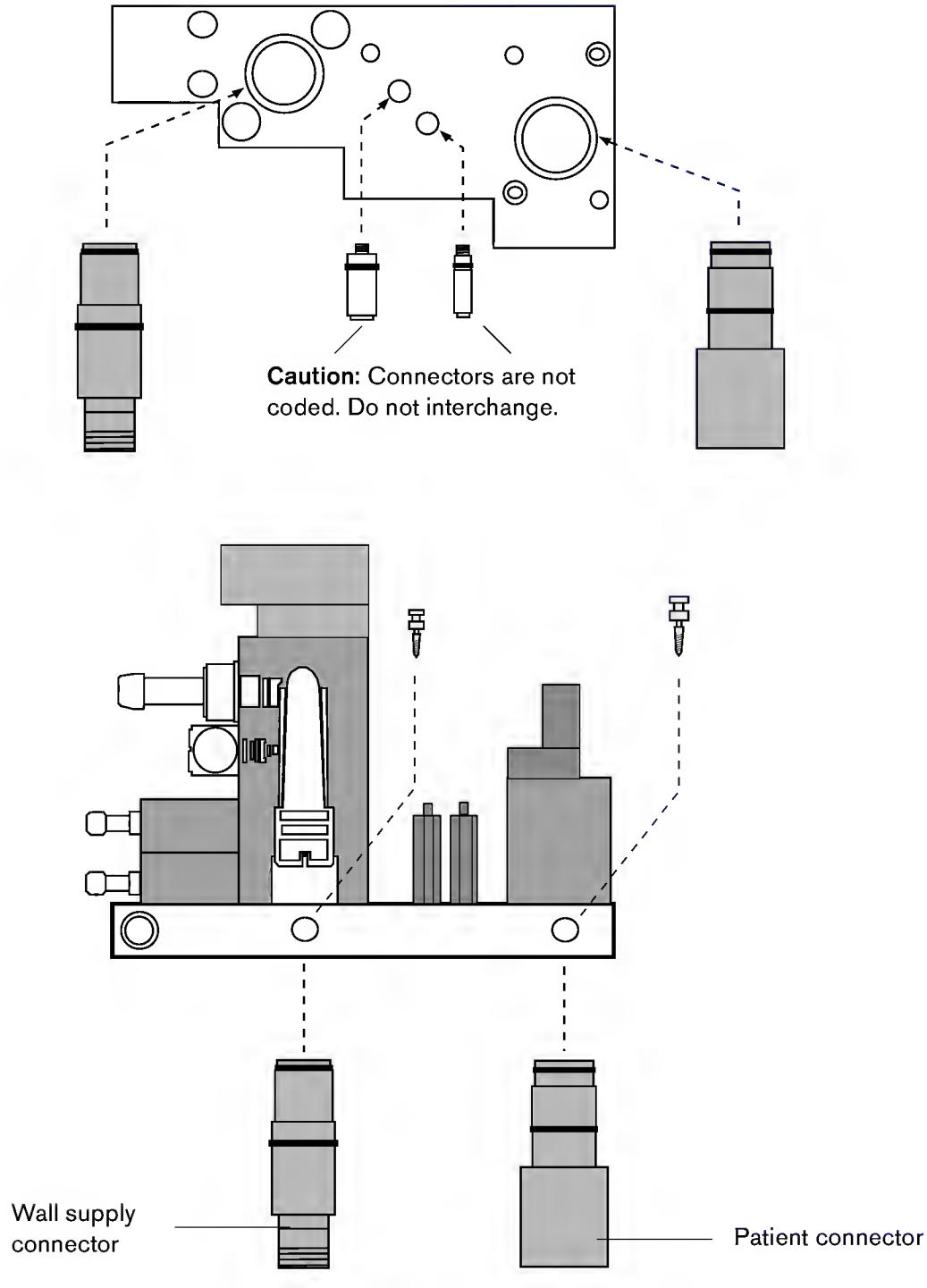

Fig. 45: Gas supply

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5.9 Control PCB

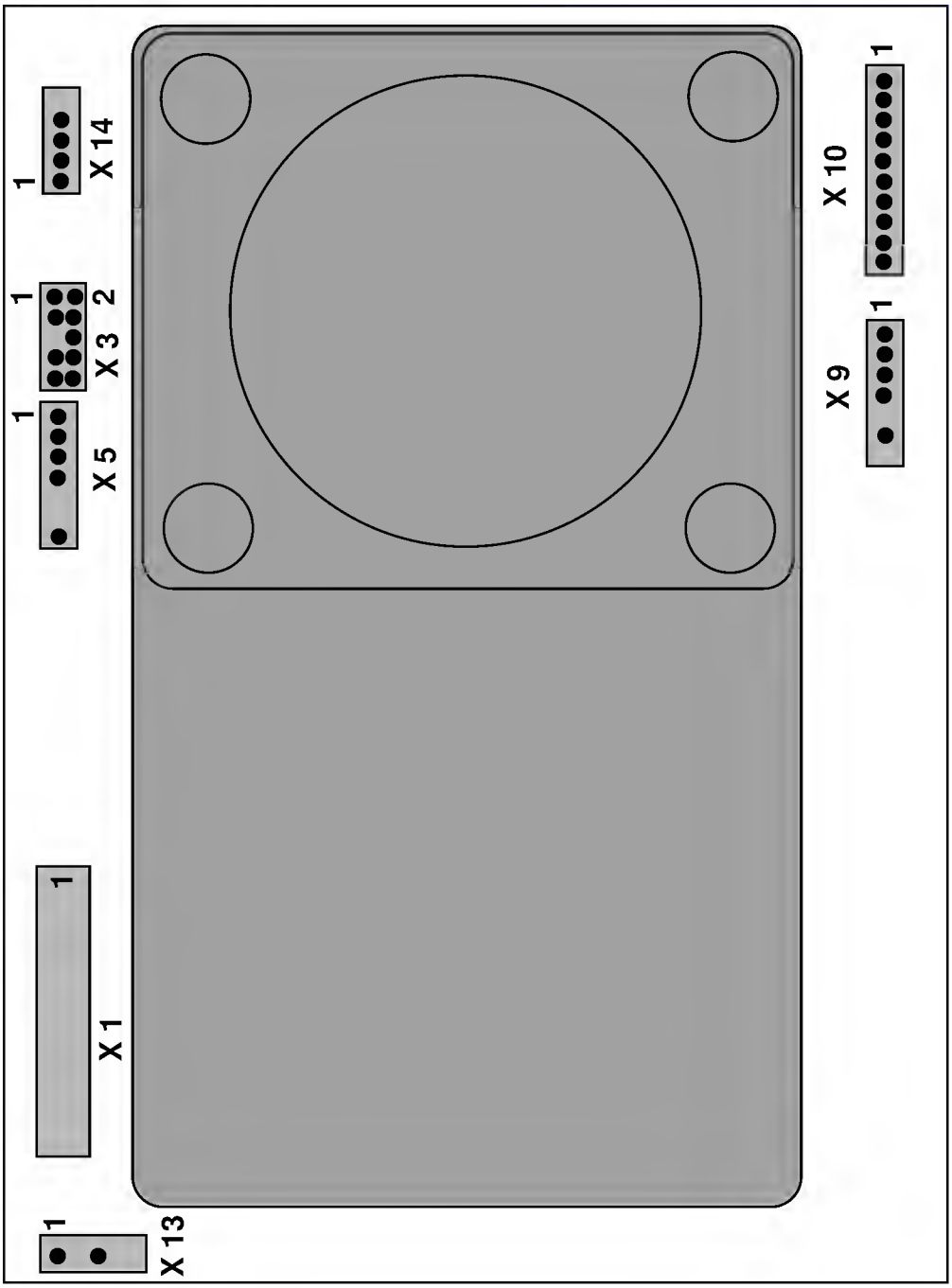

Fig. 46: Control PCB

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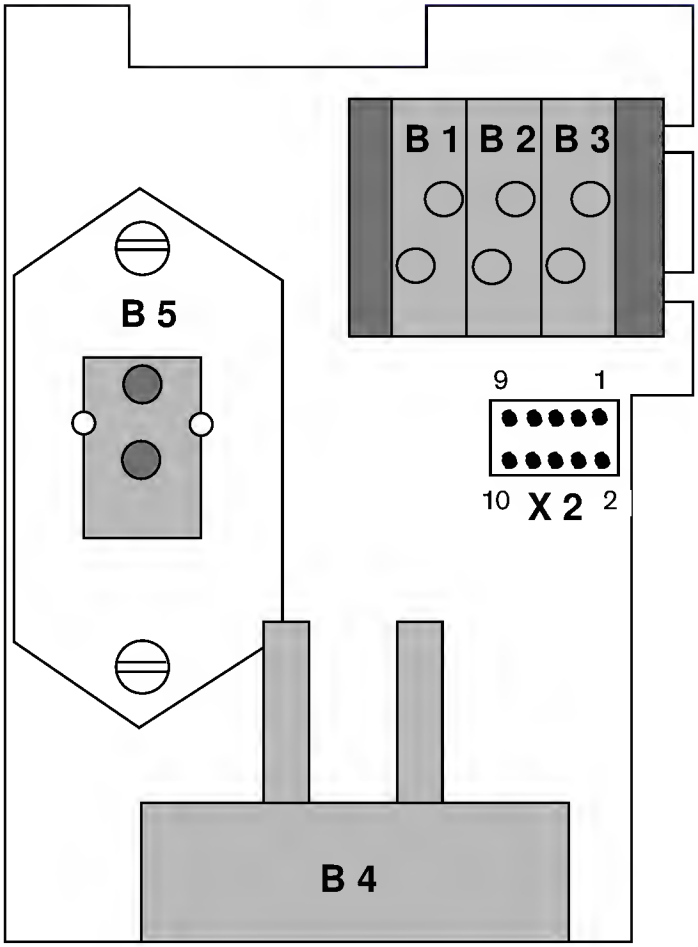
5.10 Sensor PCB



B1 P–supply
B2
B3 P–LA
B4 P-Flow
B5 P–AW

Fig. 47: Sensor PCB

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5.11 Display PCB

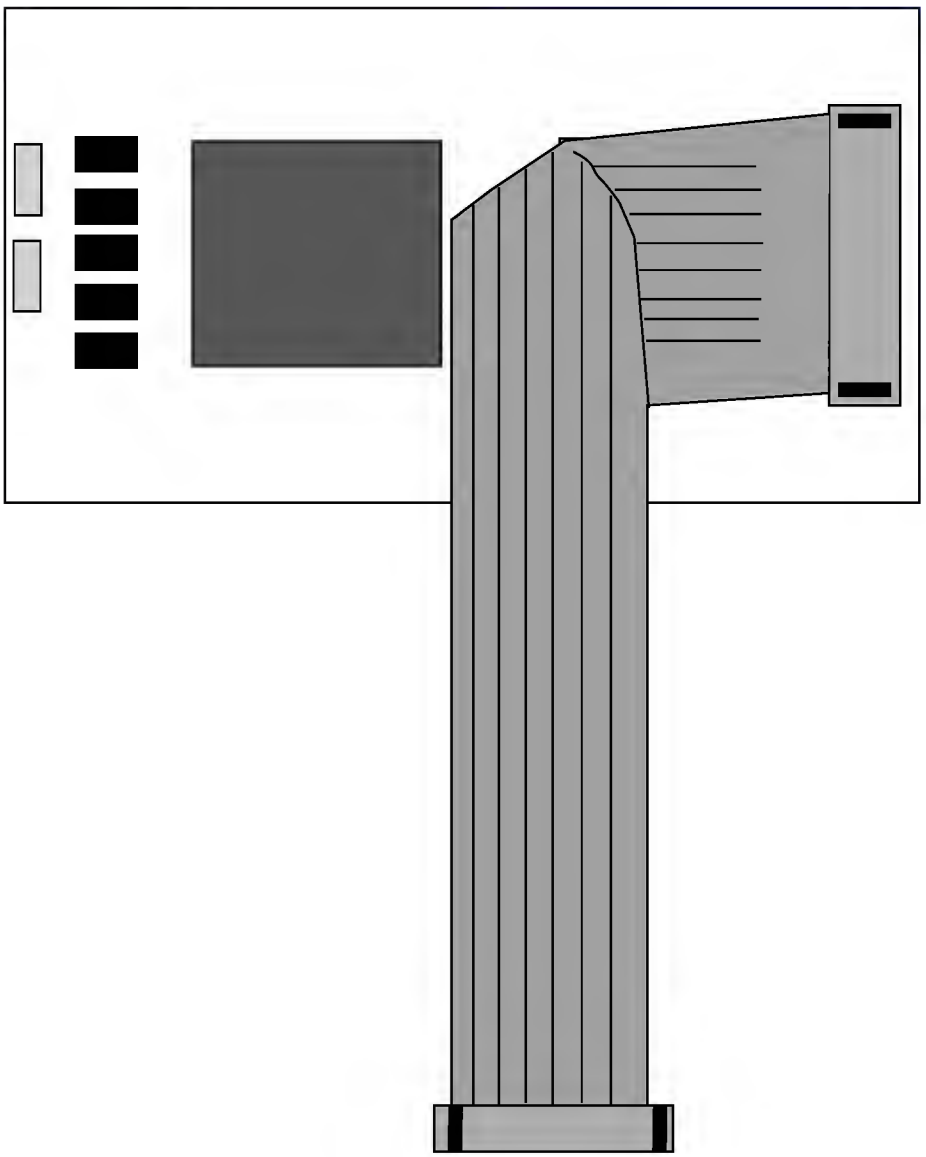

Fig. 48: Display PCB

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5.12 Fuse PCB

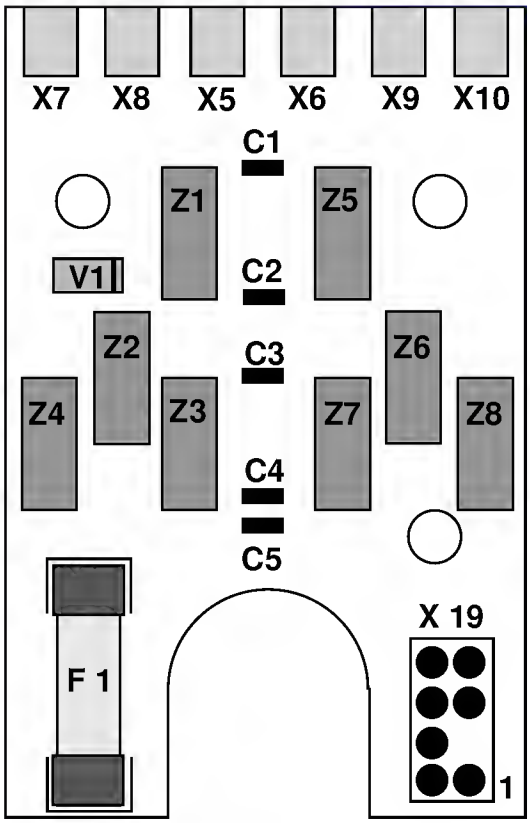

Fig. 49: Fuse PCB

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6 Function Description of the MicroVent Mixer

6.1 Assembly Drawing of the Mixer

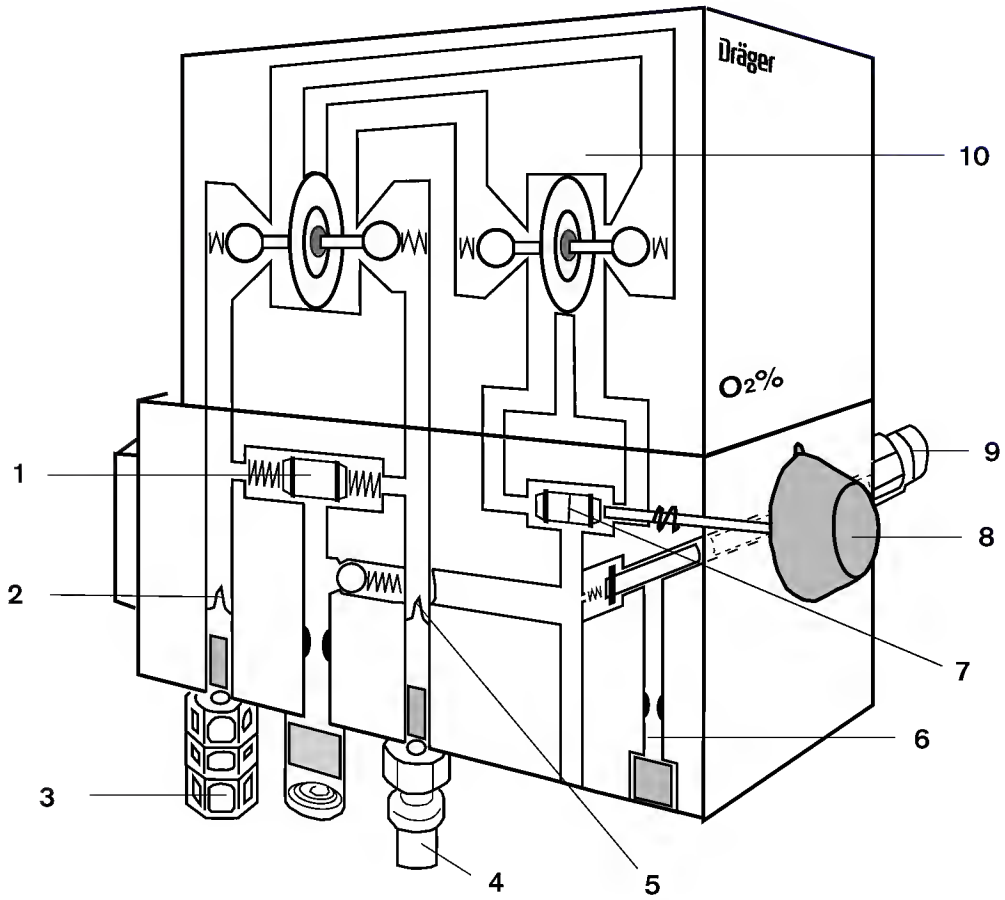

Fig.50: Assembly drawing of the mixer

Legend

1	Alarm/bypass cylinder	6	Leak flow channel
2	Air check valve	7	Restrictor
3	Air connection	8	Concentration adjuster
4	Oxygen connection	9	Mixer outlet
5	Oxygen check valve	10	Compensating module

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6.2 Gas Connection

The gas supply is connected to the air connection **1** and to the oxygen connection **2** of the mixer. Both gases are cleaned by 30 µm inlet filters. Then they pass through check valves. This prevents the gases flowing back into the central supply.

The mixer blends the air and oxygen to a desired concentration in the range of 21 to 100 vol.%.

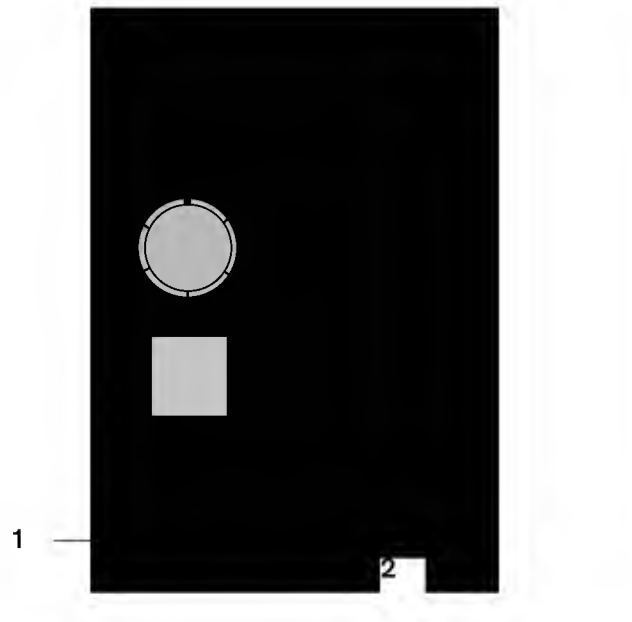

Fig.51: Front view of the mixer

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6.3 Compensating Module

The gases flow to a two-stage compensating module **3** . The compensating module ensures a pressure equilibrium between the air and the oxygen supply. The diaphragms **4** respond to a difference in pressure and, where appropriate, carry out corresponding movements inside the air or oxygen chamber. These movements control the gas quantity. Differences in gas pressure are compensated for by reducing the pressure to the lower gas pressure level.

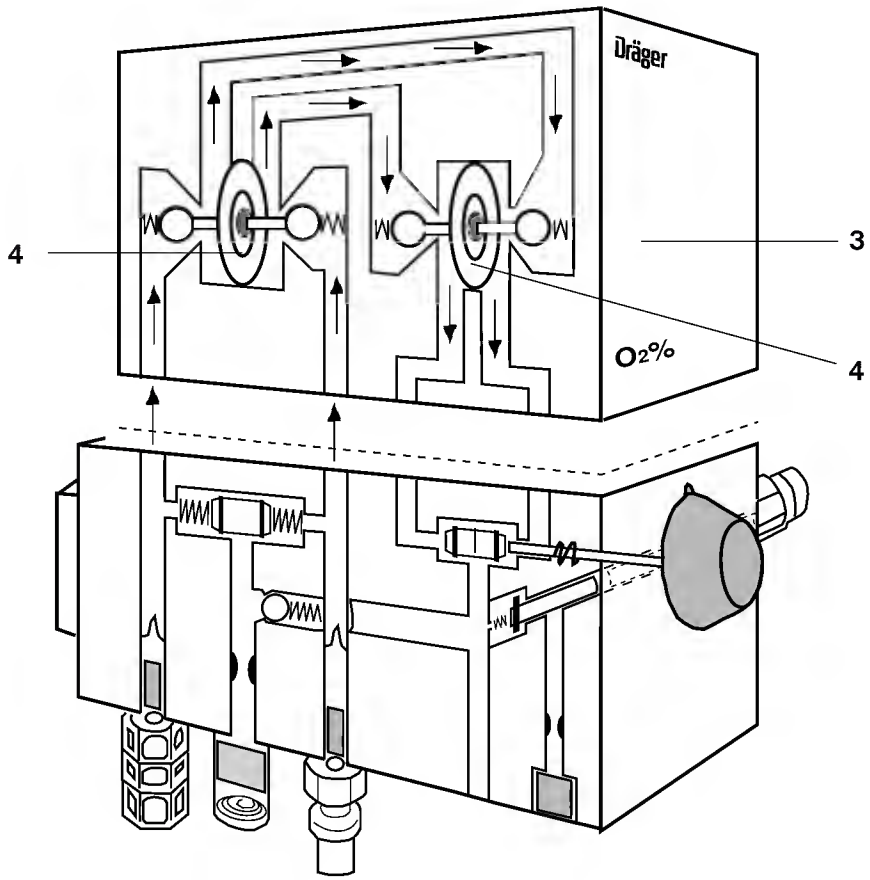

Fig.52: Compensating module

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6.4 Restrictor

After passing the compensating module, the gases reach the restrictor **5**. The gases are blended according to the adjusted O_2 concentration and then supplied to the MicroVent through the mixer outlet port **6**.

6.4.1 Components of the Restrictor

The restrictor consists of two valves which are arranged between two valve seats. One valve controls the flow rate of the air and the other controls the flow rate of the oxygen. If the flow rate of the air increases, the flow rate of the oxygen decreases, and vice versa.

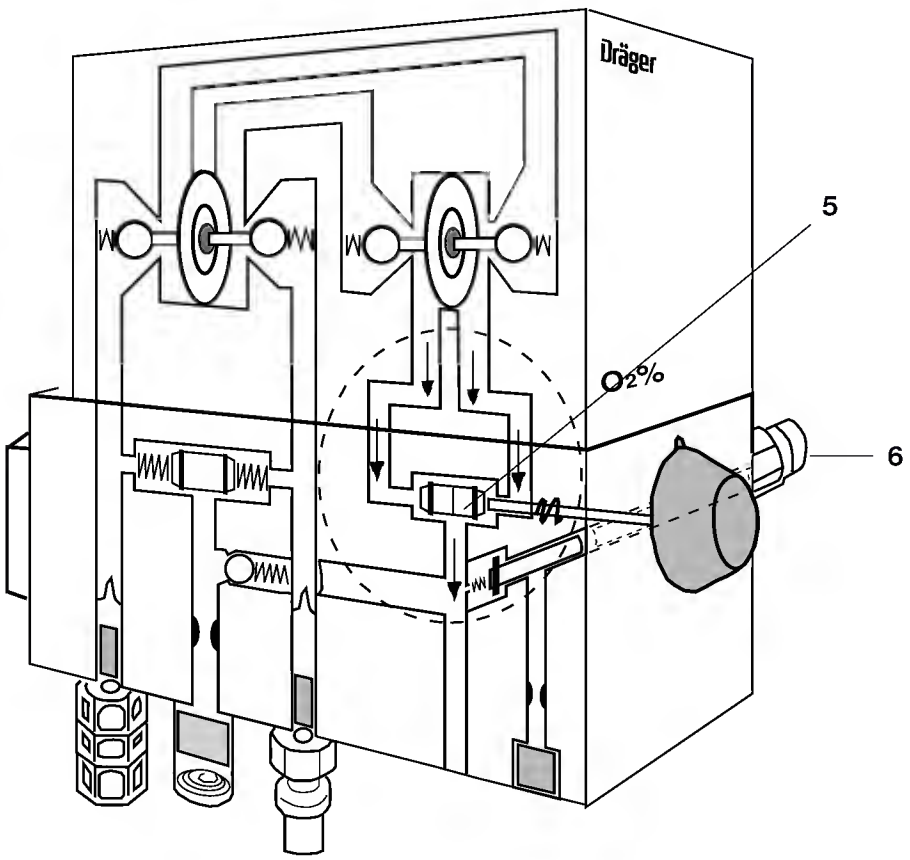

Fig.53: Restrictor of the mixer

If the concentration is set to 21 vol.%, the oxygen supply is closed. If the concentration is set to 100 vol.%, the air supply is closed.

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6.5 Alarm

If there is a difference in pressure of 1.4 bar (20 psi) respectively 2.1 bar (30 psi) between the two gases, the mixer will activate an audible alarm. This alarm indicates that there is an unacceptable decrease/increase in pressure or that one of the two gas supplies is almost exhausted.

If a compressed gas fails, the compensating stage cannot equalize the difference in pressure. The mixer will then generate an alarm.

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6.6 Alarm/Bypass Cylinder

The alarm/bypass cylinder **7** is directly connected to the air and the oxygen supplies. If a gas fails, the alarm/bypass cylinder **7** is shifted in one direction and an alarm is activated.

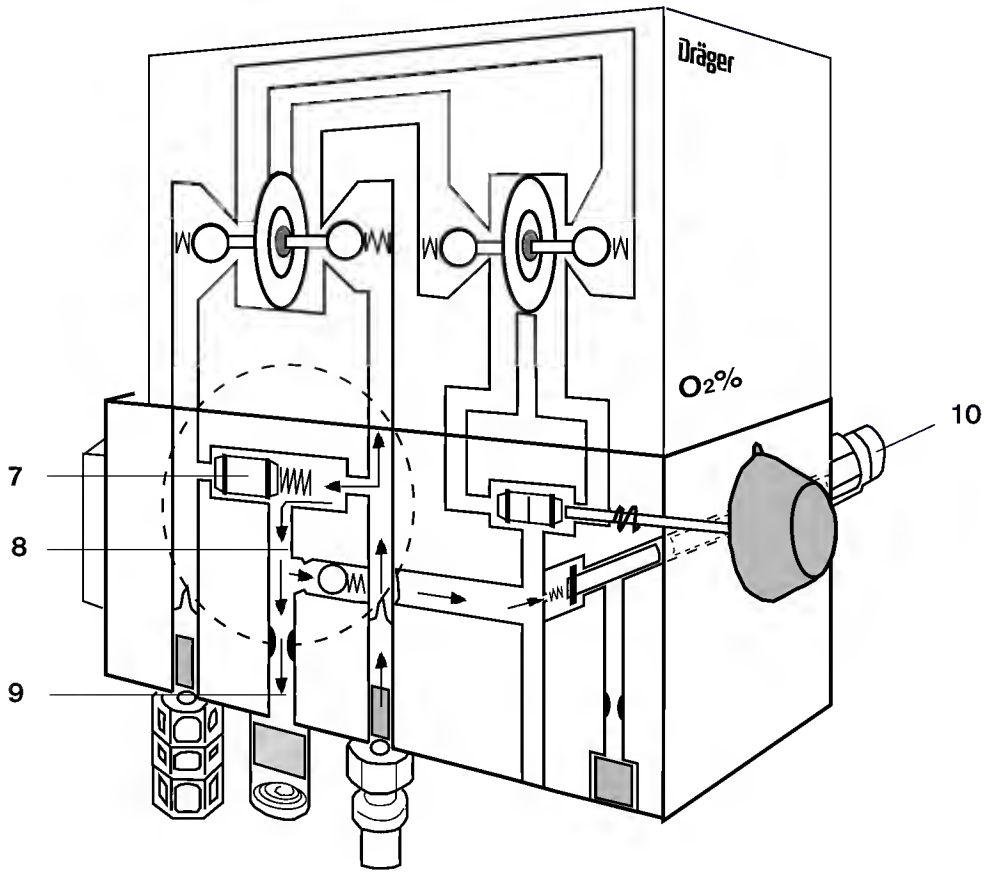

Fig.54: Alarm/bypass cylinder

If the two gases have the same pressure, the alarm/bypass cylinder **7** will be positioned in the middle of the bypass channel. The alarm/bypass cylinder remains in this position up to a pressure difference of 1.4 bar (20 psi) respectively 2.1 bar (30 psi).

If a pressure difference of more/less than 1.4 bar (20 psi) respectively 2.1 bar (30 psi) is detected, the higher gas pressure acts against a spring force. The compressed gas (air or oxygen) flows into the alarm channel **8**.

The higher-pressure gas flows to the Reed alarm **9** – where it activates an audible alarm – and to the mixer outlet **10**.

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6.7 Alarm/Bypass Mode

In the alarm/bypass mode, the mixer supplies oxygen (100 vol.% O_2) or air (21 vol.% O_2) until the alarm/bypass cylinder **7** moves back to its rest position. The alarm/bypass mode will be deactivated as soon as the pressure difference between the two gases reaches 0.4 bar (6 psi).

If the concentration is set to 21 vol.% and the oxygen supply decreases such that the pressure difference is more than 1.4 bar (20 psi) respectively 2.1 bar (30 psi), the mixer will not activate an alarm. If the concentration increases slightly, an alarm will sound.

If the concentration is set to 100 vol.% and the air supply decreases such that the pressure difference is more than 1.4 bar (20 psi) respectively 2.1 bar (30 psi), the mixer will not activate an alarm. If the concentration decreases slightly, an alarm will sound.

Important

When not in use the mixer should not be connected to the gas supply otherwise an alarm will be activated, e.g. because the pressure difference is more than 1.4 bar (20 psi) respectively 2.1 bar (30 psi). Such an alarm would be unnecessary if the mixer is not in use.

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6.8 Mixer Outlet

(see Fig. 50) allows the adjusted gas quantity to flow into the MicroVent. During this process, there is a leak flow of 10–12 L/min. This leak flow makes sure the concentration is also accurate when low flows of up to 2 L/min are applied.

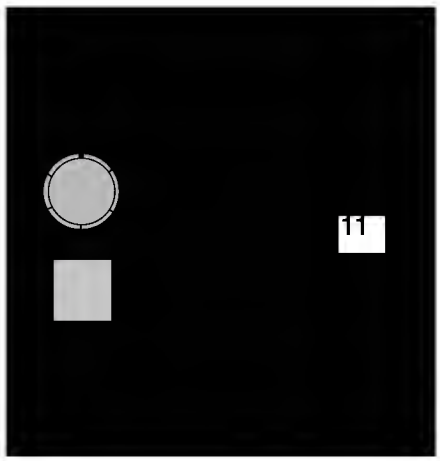

Fig.55: Mixer outlet

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